THE UPPER PERMIAN FLORA OF ENGLAND

H. M. M. STONELEY

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THE UPPER PERMIAN FLORA OF ENGLAND

By HILDA M. M. STONELEY

SYNOPSIS

The paper brings together existing information relating to the scanty flora of the Upper Permian beds of northern England. Of the 24 fossil plant species described, the majority are also known from the German Zechstein, but there are new species of the algal genera *Piaea* and *Calathella*, a new cycadophyte provisionally included in *Pseudoctenis*, and a representative of *Hiltonia*, recently described as a new genus elsewhere. Other plant remains not referable to Zechstein species closely recall *Cordaites aequalis* (Göppert) and *Psygmophyllum cuneifolium* (Kutorga), both well-known Russian Permian species; these records, however, need confirmation from more adequate material. The cuticle structure of several species is described. Leaf fragments with preserved cuticles of distinctive types show that further species are represented in the English Upper Permian, but the material is too imperfect for description. Certain non-vegetable structures previously regarded as fossil plant remains are also discussed.

1. INTRODUCTION

In England beds of established Upper Permian (Thuringian) age have two main outcrops, one east of the Pennines, extending from the south of Northumberland to near Nottingham, and the other west of the Pennines. There are also small outcrops still further west. These beds lie unconformably on Upper Carboniferous rocks which are not the latest known in this country. Rocks of intermediate age succeed the Coal Measures conformably in Warwickshire, Staffordshire and some adjacent areas. Some must unquestionably be included in the Upper Carboniferous, but the youngest, a series of red marls, sandstones and breccias known as the Enville or Corley Group, have been assigned by some writers to the Lower Permian (Autunian). They have yielded a scanty flora of which it is hoped to give an account elsewhere. No plant-bearing beds thought to be of Middle Permian (Saxonian) age occur in this country.

The Upper Permian rocks contain a flora which has hitherto been little investigated and is the subject of the present paper. Identifiable specimens are, however, very limited in number and are largely from localities no longer available for collecting. An attempt has, therefore, been made to locate and examine all such specimens found in the past. Material was collected personally, mainly at Hilton and Kimberley, where plant remains still abound but are mostly ill-preserved. The writer thanks the authorities of the following institutions for access to and the loan of specimens:

British Museum (Natural History)[1]; Geological Survey[2], Royal Scottish, Hancock (Newcastle-upon-Tyne), Yorkshire, Manchester, Carlisle, Dorman Memorial (Middlesbrough), Sunderland, Warwick, Wollaton Hall (Nottingham), and Birmingham City Museums; Geological Departments of Birmingham, Nottingham, and Leeds Universities, King's College, Newcastle-upon-Tyne, and University College, Galway (where W. King's collection is deposited). Dr. C. T. Trechmann kindly lent specimens, since presented to the British Museum (Natural History), from his own collection, and Professor R. Kräusel sent for comparison type specimens of German Upper Permian algae belonging to the Senckenberg Museum. The writer also wishes to acknowledge most helpful advice given her by Professor R. Florin and Dr. Britta Lundblad during a visit to Stockholm, and by Professor T. M. Harris. The investigation, undertaken at the suggestion of the late Mr. W. N. Edwards, was carried out with the aid of a grant from the Department of Scientific and Industrial Research in the Sedgwick Museum, Cambridge, to the authorities of which the writer tenders her thanks.

2. HISTORY OF PREVIOUS WORK ON THE ENGLISH UPPER PERMIAN FLORA

The first record of the occurrence of plant remains in English Upper Permian beds was by Sedgwick (1829 : 76, 77, 120), who mentioned the discovery of impressions of " ferns " in the Marl Slate of Middridge, S. of Bishop Auckland, during the construction of the railway. This locality long continued to yield fossil plants, including the best found in the Permian of this country. Lindley & Hutton (1837 : 123, pl. 195) described only one Permian species, *Voltzia phillipsii* [= *Ullmania frumentaria* (Schloth.)], from Whitley, Northumberland. King (1850) included descriptions and figures of the plant species *Caulerpa ? selaginoides* (Brongniart) [= *Ullmannia frumentaria*], *Neuropteris huttoniana*, and *Polysiphonia ? sternbergiana*, from Durham, and of *Chondrus binneyi* (an inorganic structure) from red Permian marls near Manchester. This work also included a brief description of that important organism (possibly an alga) of the Upper Magnesian Limestone, *Filograna ? permiana*, tentatively referred to a worm genus.

For many years Kirkby and Howse were the most active students of Durham Permian fossils. Among Kirkby's papers was an important one (1867) on the Marl Slate and Lower Magnesian Limestone with records of several fossil plants, but a more important list of Permian plants was included in Howse's (1890) catalogue of the fossils in the Museum at Newcastle (now the Hancock Museum). From the Marl Slate were recorded, besides *Ullmannia selaginoides*, two other well-known German Upper Permian species, *U. bronni* Göppert and *Zonarites digitatus* (Brongniart), a specifically unidentified *Calamites*, and two supposedly new species given the *nomina nuda Taeniopteris duffiana* and *Ctenis permiana*. From the Upper Magnesian Limestone were recorded *U. selaginoides* and a supposedly new species of *Calamites* which had been first mentioned by Kirkby (1864) and was assigned the *nomen nudum C. wakei*. The algal species *Chondrites virgatus* Münster was recorded from several horizons, but Howse seems to have confused under this name both King's

[1] Abbreviated to 'B.M.N.H.' in the systematic descriptions.

[2] The abbreviation ' G.S.M. ' is used for the Geological Survey Museum in the systematic descriptions.

Polysiphonia ? *sternbergiana* and his *Filograna* ? *permiana*. Since 1890 little attention has been paid to the Permian plants of Durham, with the exception of *Filograna* ? *permiana*, which has lately attracted notice as an index fossil of the Upper Magnesian Limestone (Trechmann, 1925, 1942, 1952 ; Dunham, 1948).

The few records of plant remains from the Permian outcrop between Co. Durham and Nottingham are mentioned on p. 299. Wilson (1876) first recorded their presence in beds exposed in the railway cuttings between Kimberley and Cinderhill, and stated (1881 : 122) that Carruthers had pronounced them to " disclose a flora known on the Continent ". Neither in these nor in later references (Gibson & others, 1908 : 104 ; Lamplugh & Gibson, 1910 : 67 ; Smith, 1913 : 215) to the presence of fossil plants in the Kimberley Marl Slates is a single specific identification cited.

Borings in Nottinghamshire and Yorkshire passing through Permian rocks east of the outcrop have brought to light a number of plant remains, hitherto almost uninvestigated. An exception is a well-preserved cone-scale of *Pseudovoltzia liebeana* (Geinitz), the structure of which was described in detail by Walton (1929).

It was not until 1862 that Harkness (p. 215) recorded the discovery of the now well-known plant beds at Hilton Beck, near Appleby, Westmorland. As identified by the palaeobotanist Heer, they included " ferns referable to *Neuropteris* and *Sphenopteris* ", among them a species close to *S. erosa* (Morris), of the Russian Permian ; remains " allied to *Weissites* (Göppert) ", as figured by Geinitz from the German Zechstein ; a form " having the aspect of *Caulerpites selaginoides* (Sternb.) "; and " detached leaves, resembling *Cupressites Ullmanni* Brongn." Two years later Murchison & Harkness (1864 : 154) published a more satisfactory list of Hilton plants, this time determined by Etheridge. The species mentioned are *Sphenopteris naumanni* Gutbier, *S. dichotoma* Althaus, *Alethopteris goepperti* Naum., *Ullmannia selaginoides, U. bronnii, Odontopteris* ? sp., *Sphenopteris* ? sp., and *Cardiocarpon triangulare* Gein. To these records Goodchild (1889) added *Walchia piniformis* (Schloth.) and *Noeggerathia cuneifolia* Geinitz, but the first may be dismissed as incorrect as the species in question belongs to the Lower Permian, while the second may also be ignored as Geinitz himself had already withdrawn this species as based on generically indeterminate remains. Brockbank (1892) described a visit to Hilton and published three plates of unnamed and mostly indeterminate plant remains. Later authors who have mentioned the Hilton plants have merely quoted Etheridge's identifications.

Ill-preserved plant remains found by Roeder in the Upper Permian Manchester Marls were submitted to Geinitz for identification (Geinitz, 1889, 1890 ; Roeder, 1890, 1890*a*, 1890*b*). The species identified were *Voltzia liebeana* Geinitz, ? *Ullmannia selaginoides* (Brongn.), and *Filograna permiana* King, together with two non-vegetable structures (*Guilielmites permianus* and *Spongillopsis dyadica*) which Geinitz had previously described from the German Permian and regarded as plant remains. In the present paper doubt is cast on the reliability of the plant determinations on account of the poorness of the material. Records of plant remains from borings in Permian rocks in SW. Cumberland are referred to on p. 303.

It is uncertain if the Permian rocks found in Devon, Shropshire, Ayrshire, northern Scotland, Ulster, and certain other areas include beds of Thuringian age, and so far they have yielded no plant remains.

3. NOTES ON THE PLANT LOCALITIES, WITH SPECIES FOUND AT EACH

(a) *Eastern Outcrop, Localities Enumerated from North to South*

Cullercoats Bay (Trechmann, 1931 : 247 ; Hickling & others, 1948 : 6). The Marl Slate, with fish and plant remains, formerly cropped out on the foreshore 50 yards from the tip of the promontory, but it has been almost entirely removed by collectors. It has yielded :

Paracalamites kutorgai (Geinitz)
Annularia ? sp.
Ullmannia frumentaria (Schlotheim)
Unidentifiable fossil wood, including large branches

Whitley. At this locality, near Cullercoats, was formerly a quarry exposing Yellow Sands overlain by Marl Slate and Lower Magnesian Limestone. It yielded the type specimen of *Voltzia phillipsi* L. & H. (= *Ullmannia frumentaria*).

Westoe, South Shields. Here was a quarry in Lower Magnesian Limestone mentioned by Kirkby (1867*a* : 188). Bedding planes were covered with *Algites sternbergianus* (King).

Fulwell Hill Quarries (Kirkby, 1864 : 345 ; Woolacott, 1912, section facing p. 260). On the north side of Sunderland and famous for concretionary structures. Here the Upper Magnesian Limestone yielded plant remains (now lost) consisting, according to Kirkby, of a stem of *Calamites*, *Ullmannia selaginoides* (= *U. frumentaria*), and a large, reed-like plant. These were a unique occurrence at this horizon.

Fulwell Water Works. A specimen of *Paracalamites kutorgai* (Geinitz) came from this locality. There is no published record of the beds that were exposed there.

Claxheugh (Kirkby, 1867 : 197 ; Woolacott, 1898 : 14 ; 1903 : 211 ; 1912, figs. 3, 4, facing p. 256). A river bluff 2 miles west of Sunderland, now in a shipbuilding yard and inaccessible. There was formerly an interesting section exposing Permian beds ranging from Yellow Sands to Middle Limestone. Specimens of *Ullmannia frumentaria* are from the Marl Slate.

Thrislington Gap (King, 1850 : xii). A railway cutting about 1 mile N. of Ferryhill Station, exposing Coal Measure Sandstone, Marl Slate and Lower Magnesian Limestone. The type locality of *Mixoneura huttoniana* (King).

Ferryhill (Calvert, 1884 : 73). Railway cuttings near the one mentioned last. From them come :

Ullmannia frumentaria (Schlotheim)
Pseudovoltzia liebeana (Geinitz)

Cornforth. Presumably from the old quarries near the village King recorded "*Caulerpa selaginoides*" (= *Ullmannia frumentaria*).

Raisby Hill Quarry (Hickling, 1931). Two miles E. of Cornforth and just north of the railway. This large quarry, 1 mile long, affords the best section of the lower beds of the Magnesian Limestone now to be seen in Durham. The Marl Slate, thickly developed at the western end, yielded the large branch of *Ullmannia bronni* Göppert represented in Pl. 38, figs. 1*a*, *b*.

Brusselton. A farm S. of Bishop Auckland with quarries near-by. Cited by King as a locality for " *Caulerpa selaginoides* " and " *Neuropteris* " *huttoniana.*

East Thickley Quarry (Trechmann, 1921). Adjoining Shildon railway station and exposing Coal Measure Sandstone, Marl Slate, and Lower Limestone. Recorded as the type locality of *Algites sternbergianus* (King), which probably came from the Lower Limestone. From the Marl Slate of this quarry come :

Ullmannia frumentaria (Schlotheim)
Pseudovoltzia liebeana (Geinitz)
Hiltonia rivuli Stoneley

Middridge (Sedgwick, 1829 : 76 ; Hancock & Howse, 1870 : 356 ; Trechmann, 1921 : 538). Quarries adjoining the railway E. of Shildon Station and S. of Middridge village formerly showed Coal Measure Sandstone succeeded by Marl Slate and Lower Limestone, but only unfossiliferous Lower Limestone is now visible. The Marl Slate at this locality was the source of the best Permian plants yet found in England. Species identified by the writer are :

Algites virgatus (*Münster*)
Taeniopteris eckhardti Kurtze
? *Psygmophyllum cuneifolium* (Kutorga)
Sphenobaiera digitata (Brongniart)
Pseudoctenis middridgensis sp. nov.
Ullmannia bronni Göppert
Ullmannia frumentaria (Schlotheim)
? *Pseudovoltzia liebeana* (Geinitz)
Hiltonia rivuli Stoneley

Glass Houghton, NW. of Pontefract, Yorks. Wilson (1881 : 122) recorded plant remains from beds underlying Lower Magnesian Limestone in sandpits at this locality. No specimens have been traced.

Glapwell, Derbyshire. Five miles NW. of Mansfield, Notts. In the Geological Survey Museum are obscure leaf impressions resembling *Ullmannia bronni* Göppert and other remains said to have come from Permian beds here.

Fackley Hill, near Skegby, Notts. (Aveline, 1861 : 5 ; Lamplugh, *in* Gibson & Wedd, 1913 : 80). The locality of leaf impressions here identified as cf. *Cordaites aequalis* (Göppert), a unique record for this country. The specimens occur as impressions in yellowish limestone.

Fulwood Top, near Sutton-in-Ashfield, Notts. About 2 miles due S. of the last locality. Aveline (1861 : 6) recorded fossil wood from sandstones representing Lower Magnesian Limestone here.

Kimberley, near Nottingham (Wilson, 1876 ; 1881, pl. 7 ; Smith, 1913, pl. 38*a* ; Carr, 1913, pl. 14*b*). Two parallel railway cuttings extending eastwards from Kimberley Station for about a mile expose Upper Coal Measure Sandstone overlain by the lower beds of the Magnesian Limestone series, with a breccia at the base. The plant-bearing Marl Slates (about 30 ft. thick) have been exposed in the more northerly cutting by a recent landslip, and the writer was able to collect from and make a

detailed measurement of the section. The following plant remains have been identified from Kimberley :

Callipteris martinsi (Kurtze)
Pseudovoltzia liebeana (Geinitz)
Hiltonia rivuli Stoneley
Strobilites bronni Solms-Laubach
Samaropsis triangularis (Geinitz)

Cinderhill. A colliery 2 miles on the Nottingham side of Kimberley. A temporary exposure here some years ago enabled Dr. H. S. Holden to collect fossil plants, now in the British Museum (Natural History), from the Marl Slate. They include isolated leaves of *Ullmannia bronni* Göppert and *U. frumentaria* (Schlotheim).

(b) *Borings and Colliery Shafts in S. Yorkshire, Lincolnshire and Nottinghamshire*

Ulleskelf Nurseries Boring (Edwards, Mitchell & Whitehead, 1950 : 81). About 8 miles NW. of Selby, Yorks. The Upper Magnesian Limestone yielded *Tubulites permianus* (King) and structures resembling *Chondrus binneyi* King.

Wressell Boring (Edwards, 1951 : 263). About 7 miles E. of Selby, Yorks. At depth 1,982 ft. the Lower Magnesian Limestone yielded a fragment of a shoot of *Pseudovoltzia liebeana* (Geinitz).

Bentley Colliery No. 2 Shaft (Edwards, 1951 : 127). Plant-bearing specimens from the Lower Marl, in the Wollaton Hall Museum, contain *Ullmannia bronni* Göppert, an unidentified fructification, and fossil wood.

Sutton Boring (Edwards, 1951 : 247). Two miles NNE. of East Retford, Notts. The Lower Marl, at depth 1,085 ft., is rich in plant remains, including the following :

Callipteris martinsi (Kurtze)
Ullmannia sp.
Pseudovoltzia liebeana (Geinitz)
Hiltonia rivuli Stoneley

West Drayton Boring. Four miles S. of East Retford. Lower Limestone at depth 1,073 ft. yielded an indeterminate conifer fragment recorded as *Pinnularia capillacea* L. & H. (Edwards, 1951 : 101).

Haughton Hall Boring. Five miles S. of East Retford. Lower Marl at depth 111 ft. yielded well-preserved leaves of *Hiltonia rivuli* Stoneley, recorded as *Cordaites* sp. by Edwards (1951 : 99).

Doddington Boring (Edwards, 1951 : 162). About 6 miles W. of Lincoln. Lower Limestone or Lower Marl (unseparated in record of boring) yielded the following :

Callipteris martinsi (Kurtze), depth 2,320 ft.
Ullmannia bronni Göppert, depths 2,300, 2,303, 2,310 ft.
Ullmannia frumentaria (Schlotheim) ?, depth 2,327 ft.
Hiltonia rivuli Stoneley, depths 2,310, 2,330 ft.

Markham Moor Boring. About 6 miles S. of East Retford. Plant remains occurred through a range of 248 ft. of Permian beds, as follows :

Piaea anglica sp. nov., depth 1,140 ft.
Piaea sp., depth 1,105 ft.
Calathella dictyonemoides sp. nov., depth 1,056 ft.
Ullmannia frumentaria (Schlotheim), depth 1,055 ft.
Ullmannia sp., depths 1,046 ft., 1,047 ft.
Pseudovoltzia liebeana (Geinitz), depth 1,105 ft.
Hiltonia rivuli Stoneley, depth 1,294 ft.

Thoresby Colliery Shaft. About 7 miles NE. of Mansfield, Notts. *Ullmannia frumentaria* (Schlotheim), depth unrecorded.

Wellow Boring (Edwards, 1951 : 259). About 14 miles S. of East Retford. *Ullmannia bronni* Göppert from Lower Marl or Lower Limestone at an unrecorded depth.

Farnsfield Boring (Edwards, 1951 : 167). About 9 miles W. of Newark. Cuticle preparations made by Professor R. Florin from bulk-macerated material from Lower Limestone yielded, besides several new cuticle types, the following :

Ullmannia sp.
Hiltonia rivuli Stoneley

Calverton Colliery Shaft. About 5 miles NNE. of Nottingham. Material labelled " Marl Slates 134–152 yards " has yielded the following :

Callipteris martinsi (Kurtze)
Ullmannia bronni Göppert

Lowdham (or Cliff Mill) Boring (Edwards, 1951 : 201). About 7 miles ENE. of Nottingham. Unidentifiable plant remains were found in Middle Marl at depth 688 ft. and in Lower Marl at depth 782 ft.

Bulcote Boring (Edwards, 1951 : 140). Six miles ENE. of Nottingham. Lower Marl at depth 711 ft., 1 ft. above the Basal Breccia, yielded the interesting fossil, *Conites* sp. (p. 329).

(c) *Eden Valley (Westmorland and SE. Cumberland)*

Hilton Beck. The chief exposure of Hilton Plant Beds is in a low cliff near the southern bank of Hilton Beck at a spot called Ash Bank, about ½ mile W. of Hilton village and close to the road to Appleby. The strata are also exposed along the stream course, and in the northern bank, just above the Penrith Sandstone, was found a bed full of well-preserved leaves, study of which gave the clue to the existence of the genus *Hiltonia*. The plant beds consist of sandstones, which frequently are current-bedded and have ripple-marked surfaces, and of shales, often finely laminated and highly micaceous. No fossils other than plant remains were found during several days' collecting. The list from this locality is :

Callipteris martinsi (Kurtze)
Sphenopteris bipinnata (Münster)
Schützia ? sp.
Sphenobaiera digitata (Brongniart)
Ullmannia bronni Göppert

Ullmannia frumentaria (Schlotheim)
Pseudovoltzia liebeana (Geinitz)
Hiltonia rivuli Stoneley
Strobilites bronni Solms-Laubach
Strobilites ludwigi (Weigelt)

Murchison & Harkness (1864 : 154) recorded the seed *Cardiocarpon* (now *Samaropsis*) *triangularis* Geinitz from Hilton, but the specimen recorded (Geological Survey Museum) is not that species and may not be a seed. The writer has collected small cordate seeds at Hilton.

Belah Brook (Eccles, 1871 : 34). Plant beds occur in the section exposed along this stream between Belah Bridge, Brough Sowerby, and Robridding. They consist of grey micaceous shale rich in plant remains which, however, are even more ill-preserved than those at Hilton. The following species are represented in material collected at Belah Brook in August 1957 :

Callipteris martinsi (Kurtze)
Ullmannia bronni (Göppert)
Ullmannia frumentaria (Schlotheim)
Pseudovoltzia liebeana (Geinitz)
Hiltonia rivuli Stoneley
Strobilites bronni Solms-Laubach

Birkshead Gypsum Mine, Marton Moor. Three and a half miles N. of Appleby. Plant remains are associated with the gypsum and may be seen in the roof of the mine. The following species were collected in August 1957 :

Callipteris martinsi (Kurtze)
Pseudovoltzia liebeana (Geinitz)
Hiltonia rivuli Stoneley

Opencast Gypsum Mine (*Thos. M'Ghie & Sons*), 1 *mile E. of Kirkby Thore.* Situated $4\frac{1}{4}$ miles NNW. of Appleby. About 5 ft. of plant beds occur just above " gypsum bed B " of Hollingworth, and have yielded *Hiltonia rivuli* Stoneley.

Acorn Bank Gypsum Pit (Russell, *in* Dakyns, Tiddeman & Goodchild, 1897 : 81). Situated NNE. of Temple Sowerby. Penrith Sandstone is overlain by 20 ft. of massive gypsum, and this by shale with ill-preserved plants. From the gypsum itself came the remarkable specimen of *Callipteris martinsi* (Kurtze) illustrated in Text-fig. 5*d* (p. 313).

Little Salkeld. Five and three-quarter miles NE. of Penrith. A few specimens from Hilton Plant Beds at this locality are in the Carlisle Museum. They include leaves of the following :

Ullmannia bronni Göppert
Ullmannia frumentaria (Schlotheim)
Hiltonia rivuli Stoneley

(d) *Manchester District*

Fallowfield (Roeder, 1892). A railway cutting $3\frac{1}{4}$ miles S. of the centre of Manchester.

From the red marl at this locality Geinitz (1889, 1890) identified *Voltzia liebeana* Geinitz and *Guilielmites permianus* Geinitz, and, from limestone bands, *Filograna permiana* King. Specimens in the Manchester Museum labelled as the first species are now indeterminate, *Guilielmites* is an inorganic structure, and the identification of the last species is uncertain. The best specimen seen from here is a red marl impression of a small shoot with broad, linguiform leaves recalling those of *Hiltonia rivuli* Stoneley.

(e) *South-West Cumberland and Furness*

Old Layriggs Borehole, Kirksanton (Smith, 1919 : 17). Obscure plant remains were found in sandy shale between depths 227 ft. and 243 ft.

Haverigg Haws Borehole, near Kirksanton (Dunham & Rose, 1949 : 20). Dark grey shales at depth 1,675 ft. overlying Lower Brockram yielded plant remains recorded as *Ullmannia bronni*, but actually *Callipteris martinsi* (Kurtze).

Davy Street Boring, Barrow (Dunham & Rose, 1949 : 21). Plant remains, not traced, occurred in grey shale between depths 2,786 ft. and 2,790 ft.

4. STRATIGRAPHICAL AND GEOGRAPHICAL DISTRIBUTION OF THE PLANTS DESCRIBED

The following are lists of the fossil plant species from (*a*) the Marl Slate or approximately equivalent beds near the base of the Magnesian Limestone Series in eastern England (either along the outcrop or in borings) from the south of Northumberland to near Nottingham ; (*b*) higher Permian beds in the same area ; (*c*) the Hilton Plant Beds. Plant remains from the Manchester Marls and from Furness and SW. Cumberland are too scanty to be considered here.

Marl Slate or Approximately Equivalent Beds in Eastern Area

Algites virgatus (Münster)
Paracalamites kutorgai (Geinitz)
Annularia ? sp.
Callipteris martinsi (Kurtze)
Mixoneura sp. (*huttoniana* (King))
Taeniopteris eckardti Kurtze
? *Psygmophyllum cuneifolium* (Kutorga)
Conites sp.
Sphenobaiera digitata (Brongniart)
Cordaites aequalis (Göppert)
Pseudoctenis middridgensis sp. nov.
Ullmannia bronni Göppert
Ullmannia frumentaria (Schlotheim)
Hiltonia rivuli Stoneley
Pseudovoltzia liebeana (Geinitz)
Strobilites bronni Solms-Laubach
Samaropsis triangularis (Geinitz)

Higher Beds in Eastern Area

Piaea anglica sp. nov. Horizon not yet certain.
Calathella dictyonemoides sp. nov. Ditto.
Algites sternbergianus (King). Lower Limestone.
Tubulites permianus (King). Upper Limestone.
Paracalamites kutorgai (Geinitz). Upper Limestone.
Ullmannia frumentaria (Schlotheim). Upper Limestone.

Hilton Plant Beds

Callipteris martinsi (Kurtze)
Sphenopteris bipinnata (Münster)
Schützia ? sp.
Sphenobaiera digitata (Brongniart)
Ullmannia bronni Göppert
Ullmannia frumentaria (Schlotheim)
Hiltonia rivuli Stoneley
Pseudovoltzia liebeana (Geinitz)
Strobilites bronni Solms-Laubach
Strobilites ludwigi (Weigelt)

5. FLORAL EVIDENCE ON CORRELATION OF ENGLISH UPPER PERMIAN ROCKS

The marine Upper Permian beds of England were probably laid down in the same sea as the German Zechstein. The following are the subdivisions of the latter formation in Thuringia :

Oberer Zechstein
Obere Letten
Plattendolomit
Untere Letten
Mittlerer Zechstein
Hauptdolomit
Unterer Zechstein
Zechsteinkalk
Kupferschiefer
Zechsteinkonglomerat

The palaeontological investigation of these deposits has been much more thorough than in the case of the English Permian beds, but the number of fossil plant species known to occur in them is not great. The majority have been found only in the Kupferschiefer, but a few species range upwards. Fossil plants are not infrequent in the Upper Zechstein, although apparently they are not common in the intermediate beds. The following is a list of species which have been described from the Kupferschiefer, omitting synonyms and Weigelt's two species of the unsatisfactory genus *Archaeopodocarpus*, which appear to have been founded mainly on specimens of *Ullmannia frumentaria*.

List of Fossil Plants of the German Kupferschiefer

Algites virgatus (Münster)
Paracalamites kutorgai (Geinitz)
Sphenopteris geinitzi Göppert
Sphenopteris bipinnata (Münster)
Sphenopteris kukukiana Gothan & Nagalhard
Sphenopteris gibbelsi Gothan & Nagalhard
Sphenopteris gothani Weigelt
Sphenopteris densifolia Weigelt
Sphenopteris röpkei Weigelt
Sphenopteris gillitzeri Weigelt
Odontopteris goepperti Weiss
Callipteris martinsi (Kurtze)
Taeniopteris eckardti Kurtze
Sphenobaiera digitata (Brongniart)
Cordaites pangerti Weigelt
Ullmannia bronni Göppert
Ullmannia frumentaria (Schlotheim)
Ullmannia orobiformis (Schlotheim) (doubtful species)
Pseudovoltzia liebeana (Geinitz)
Strobilites bronni Solms-Laubach
Strobilites ludwigi (Weigelt)
Strobilites major Weigelt
Strobilites elongatus Weigelt
Strobilites minor Weigelt
Strobilites dentatus Weigelt
Samaropsis triangularis (Geinitz)
Cyclocarpon eiselianum Geinitz
Carpolithes rotherianus Geinitz

The following is a list of fossil plants recorded from the Upper Zechstein. The chief localities are in Hesse (including the deposits at Frankenberg from which *Ullmannia bronni* was first described) and Saxony (Schuster, 1933).

List of Fossil Plants of the Upper Zechstein

Sphaerococcites dyadiccus Sterzel
Piaea punctata Florin. Obere Letten.
Piaea gigantea Florin. Obere Letten.
Calathella kräuseli Florin. Obere Letten.
Algites virgatus (Münster)
Tubulites permianus (King). Plattendolomit.
Sphenopteris sterzeli Schuster. Plattendolomit.
Sphenopteris sp. I, Schuster. Obere Letten.
Callipteris martinsi (Kurtze)

Taeniopteris eckardti Kurtze. Untere Letten.
Ullmannia bronni Göppert. Untere Letten and Plattendolomit.
Ullmannia frumentaria (Schlotheim). Untere Letten, Plattendolomit and Obere Letten.
Pseudovoltzia liebeana (Geinitz). Plattendolomit and Obere Letten.
Strobilites bronni Solms-Laubach
Cyclocarpus spongioides Geinitz
Rhabdocarpus klockeanus Geinitz. Plattendolomit.

The possibility must not be overlooked that deposition of the basal member of the Upper Permian series in the eastern counties of England may have been diachronous, as Sherlock and others have suggested. The view is here taken, however, that any time that may have elapsed between the incoming of marine conditions at different localities was not great in comparison with the duration of Upper Permian time, so that species found at all the localities may be considered together. The great majority of the plants in the first of the foregoing lists have, moreover, been found in the Marl Slate at the same Durham locality, Middridge.

It has always been considered that the Marl Slate should be correlated with the German Kupferschiefer. Their stratigraphical positions are similar, separated as they are from the base of the Upper Permian succession only by a basal breccia or by sands, and they are similarly rich in fossil fishes and plant remains. The flora of the Marl Slate supports this conclusion, for several species are common to this formation and to the Kupferschiefer. The stratigraphical importance of some of these species is, however, limited, for the ranges of *Callipteris martinsi*, *Taeniopteris eckardti*, *Ullmannia bronni*, *U. frumentaria* and *Pseudovoltzia liebeana* extend to the Upper Zechstein, while *Paracalamites kutorgai*, although not recorded from the Upper Zechstein in Germany, occurs in England in the Upper Magnesian Limestone, if (as is probable) an untraced "*Calamites*" recorded by Kirkby belonged to this species. *Sphenobaiera digitata* and the seed *Samaropsis triangularis*, both common to the Kupferschiefer and the Marl Slate, have not, however, been found in the Upper Zechstein.

Of great interest, however, is the occurrence in the Marl Slate of certain species not known from the Kupferschiefer or any other horizon in Germany. Two of these, *Hiltonia rivuli* (abundant in England) and *Pseudoctenis middridgensis*, are new, while *Mixoneura huttoniana*, known only by isolated leaves, was described long ago by King (1850). An important discovery is that of specimens possibly belonging to *Psygmophyllum cuneifolium*, previously known only from the Permian of the Urals. A leaf which seems to belong to the well-known species *Cordaites aequalis*, from Central Asia, Pechoraland, and Siberia, and barely distinguishable from the widespread Gondwana species *Noeggerathiopsis hislopi*, comes from near the base of the Upper Permian at a locality in Nottinghamshire which deserves further investigation.

The re-appearance of *Ullmannia* in the Upper Magnesian Limestone of Durham is in agreement with our knowledge of its range in the German Zechstein. The most important fossil plants found at horizons above the Marl Slate in the English beds are, however, the algae. *Tubulites permianus* (hitherto called *Filograna permiana*

in England) is an index fossil of the Upper Magnesian Limestone throughout Durham, Yorkshire and Nottinghamshire, and occurs in similar abundance in Germany in the Plattendolomit, confirming the correlation of the English and German beds. In Germany the algal genera *Piaea* and *Calathella* have been found only in the Obere Letten of the Upper Zechstein. The beds in the Nottinghamshire borehole in which they occur, although not assigned to their exact stratigraphical positions, are well above the base of the Upper Permian.

Earlier workers considered that the Hilton Plant Beds should be correlated with the Marl Slate and with the Kupferschiefer, but Trotter & Hollingworth (1932 : 124) put forward the view that they are the equivalent of the Middle Permian Marl of Durham. This conclusion was based on a comparison of the lithological succession in the two areas, the fossil plants being considered useless for correlation. While several plant species range throughout the Zechstein, three found at Hilton (*Sphenopteris bipinnata*, *Sphenobaiera digitata* and *Strobilites ludwigi*) have been recorded only from the Kupferschiefer in Germany, and so support the earlier view as to the age of the Hilton beds. *Hiltonia rivuli*, moreover, is common to the Hilton beds and the Marl Slate and is not known from later beds east of the Pennines.

6. SYSTEMATIC DESCRIPTIONS

THALLOPHYTA

ALGAE

Genus ***PIAEA*** Florin, 1929

Piaea anglica sp. nov.

(Pl. 36, fig. 3)

Diagnosis. A *Piaea* with axes unbranched in their upper parts ; axes about 1 mm. wide, bearing whorls of filaments at intervals of about 0·25 mm.; filaments about 10 in a whorl, up to 2 mm. long, and mostly arising at an angle of about 60°.

Occurrence and material. Magnesian Limestone Series, Markham Moor borehole, Notts. (p. 300) ; types (G.S.M. no. 76607) from depth 1,140 ft.; a single specimen from depth 1,105 ft.

Description. There are about 30 axes lying mostly parallel on a bedding plane in a core ; those shown in the figure are typical. The length of the longest fragment is 5 cm. None is branched ; the lower parts, however, are not seen, being broken or outside the core. Two axes show in places transverse rows of dots thought to have been bases of the lateral filaments ; the number (about 4) visible in each row suggests that there were about 10 in a complete whorl. The substance is carbonaceous and there is no evidence of original calcification.

Comparison. Professor R. Kräusel kindly sent me the original specimens of *Piaea punctata* Florin (1929) from the Zechstein. Though very similar to the English specimens, they have narrower axes, shorter filaments and more conspicuous filament scars, and they branch freely.

Genus *CALATHELLA* Florin, 1929

Calathella dictyonemoides sp. nov.

(Pl. 36, fig. 4 ; Text-figs. 1, 2)

Diagnosis. A *Calathella* with longitudinal strands, 0·2–0·3 mm. wide, connected by transverse strands of the same width to form meshes mostly rectangular and about 0·5 mm. long and 0·2–0·3 mm. wide.

Occurrence and material. Magnesian Limestone Series, Markham Moor borehole, Notts. (p. 300) ; core with several specimens (G.S.M. no. 76608) from depth 1,056 ft.

Description. The figures show all that can be seen of two typical specimens. With them is associated a second type of structure (Text-fig. 2) which may be a different part of the same plant. It consists of a group of axes diverging fan-wise from

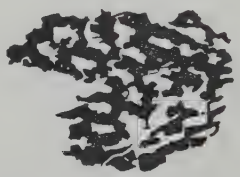


Fig. 1. *Calathella dictyonemoides* sp. nov. Magnesian Limestone Series ; depth 1,056 ft., Markham Moor borehole. Geological Survey, no. 76608. × 5.

a point. These axes vary in width, the majority between 0·1 and 0·2 mm., and some are narrowest near the base. They are often curved and occasionally fork, but are not joined by cross-connections.

Comparison. The original specimens of *C. kräuseli* Florin from the Zechstein bear at their apices what seem to be basket-shaped bodies composed of anastomosing

Fig. 2. *Calathella dictyonemoides* sp. nov. Rectangular mesh (at top) and associated structures. Magnesian Limestone Series ; depth 1,056 ft., Markham Moor borehole. Geological Survey, no. 76608. × 2·5.

strands. These bodies somewhat resemble the English specimens but have narrower strands. At the apex of one specimen of *C. kräuseli* is a bunch of narrow, irregularly spreading filaments like those arising from the lower parts of axes in that species. The

brush-like structures in the material now described may similarly have been terminal on some axes.

The new specific name recalls the graptolite *Dictyonema* for which the present specimens were originally mistaken.

Genus *ALGITES* Seward, 1894

Algites virgatus (Münster)

(Text-fig. 3)

1842 *Chondrites virgatus* Münster, p. 102, pl. 15, fig. 18.
1862 *Chondrites virgatus* Münst.: Geinitz, p. 132, pl. 24, fig. 5.

English occurrence and material. Marl Slate, Middridge, Durham; one specimen (Hancock Museum).

Description. The figure shows all the features that can be seen. The distal ends of some axes seem to bear plume-like structures, but no details are visible.

Comparison. The holotype from the Kupferschiefer is in the Palaeontological

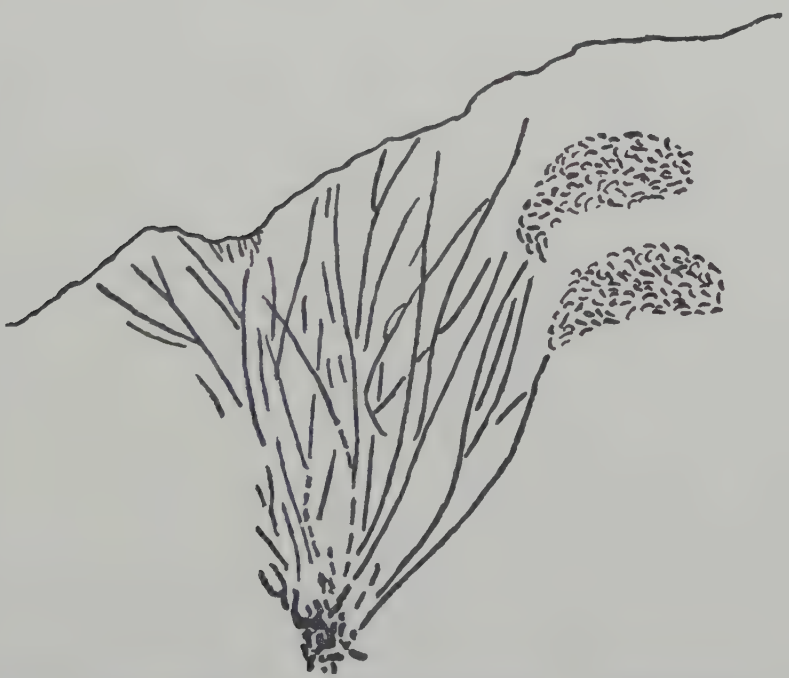


Fig. 3. *Algites virgatus* (Münster). Marl Slate, Middridge. Hancock Museum. × 2.

Department of the British Museum (no. 46674). It much resembles the English specimen, and the axes, some of which seem to branch, bear some sort of rounded body at the apex; these bodies are, however, smaller than the "plumes" of the English specimen.

It is clear from the recent paper by Simpson (1957) that the generic name *Chondrites*

Sternberg should not be used for true algal structures. It is here replaced by *Algites* Seward.

Algites sternbergianus (King)

(Pl. 36, figs. 1, 2, 5)

1850 *Polysiphonia* (?) *Sternbergiana* King, p. 3, pl. 1, fig. 2.
1867*a* *Chondrites virgatus* Münster: Kirkby, pp. 192, 197.
1890 *Chondrites virgatus* Münster: Howse, pp. 244, 248.

Occurrence and material. Lower Magnesian Limestone of Westoe, South Shields; numerous specimens in the Hancock, Geological Survey, and Manchester Museums. Also recorded (as *C. virgatus*) from Claxheugh. The holotype (not traced) was stated by King to be from the Marl Slate of Thickley, but was probably from the Lower Magnesian Limestone.

Description. The specimens are axes up to 1 mm. wide and 8 cm. long, straight or curved but not branched. Some are naked but others are clothed with irregular fine filaments up to 1 cm. long, and some bear a brush of these filaments at their distal end. No scars of filaments can be seen on the naked axes.

Remarks. These specimens are too imperfectly characterized to be placed in a more definite genus such as *Calathella*. It is to be noted that Geinitz (1858 : 6; 1862 : 132) thought this species inseparable from *A. virgatus*, and in this he was followed by Kirkby, Howse, and others. To me they seem different.

Genus *TUBULITES* Bein, 1932

Tubulites permianus (King)

(Pl. 36, figs. 6–9)

1850 *Filograna* (?) *Permiana* King, p. 56.
1861 *Filograna Permiana* King: Geinitz, p. 41.
1932 "Stäbchenkalk", Prager, p. 358, pl. 9, figs. 1–3.
1932 *Tubulites articulatus* Bein, p. 798, pl. 27, figs. 3, 4.
1934 *Tubulites articulatus* Bein: Naumann, p. 194, pl. 13*a*, fig. 1.
1942 *Filograna* (?) *permiana* King: Trechmann, p. 317.
1948 *Filograna permiana* King: Dunham, p. 220, pl. 10, fig. 3.
1952 *Filograna permiana* King: Trechmann, p. 307.

Occurrence and material. Upper Magnesian Limestone throughout Durham and Yorkshire. Localities of specimens studied are Blackhall Rocks, 5 miles N. of Hartlepool (material from here includes King's types, University College, Galway, nos. 130, 131); shore at Easington, Durham (B.M.N.H., C. T. Trechmann Colln.); Low Park Farm, Yorks.; east of Hepworth Wood, Yorks.; near Toulson Lodge, Yorks.; and near Cross Newton, Doncaster (last four, G.S.M.). Borehole material is from depth 4,240 ft., Eskdale, near Whitby (G.S.M.); also recorded from depth 638 ft., Sutton borehole, Notts. (Edwards, 1951 : 102). Very doubtful specimens (Manchester Mus. nos. L.706, L.12336) from the Manchester Marls of Strangeways and Fallowfield, near Manchester, have also been examined; they were the basis of records by Geinitz (1890 : 548) and Roeder (1892 : 15).

DESCRIPTION. The broken calcareous tubes from Easington shown in Pl. 36, fig. 7, are typical of this abundant organism ; they are 0·5 mm. wide and up to 7 mm. long. No carbon is present in them and there is no fine sculpture of any kind. Specimens were examined in thin section, but the original structure was not clear on account of metasomatic changes. The calcareous wall of the tube is usually 30–40 μ thick and in one case an inner tube 100 μ thick was observed. In no instance are the tubes arranged like strings of beads. Specimens from the Eskdale borehole are a little wider (0·75 mm.). The length of the longest single tube seen from any locality was about 2 cm.

Some specimens from Blackhall Rocks (Pl. 36, fig. 6) are only 0·3 mm. wide and may occur in bundles, sometimes as many as 24 side by side ; one bundle of 5 can be traced for 2 cm. There is a suggestion that certain of these groups may arise by the branching of one tube. It is not certain that all the specimens mentioned are specifically identical.

DISCUSSION. King gave no figure of this organism, which he referred with doubt to a genus of living worms, *Filograna*, and his description was too brief to distinguish it. His type specimens (kindly lent to me by Professor J. Mitchell) are too eroded to be worth figuring here, but show that the species has been correctly identified by modern authors. Kirkby (1861 : 309), however, who gave a description of this organism, seems not to have known of King's name for it, while Howse (1890), in a list, doubtfully placed *Filograna permiana* as a synonym of *Chondrites virgatus*. Trechmann (1925), who revived the name *F. permiana*, called attention to the importance of the organism as a characteristic fossil of the Upper Magnesian Limestone, and considered it an alga because he occasionally saw one tube branching out of another. None of the specimens I have seen, however, shows this feature unmistakably.

In 1932 Prager gave the name " Stäbchenkalk " to an Upper Zechstein limestone full of tubes 1 mm. wide and up to 8 mm. long. In the same year Bein gave reasons for considering them algal and assigned to them the new name *Tubulites articulatus* in ignorance of the earlier name for English specimens. Bein (1932) and Naumann (1934) noted the frequent presence of an inner tube inside the outer one.

PTERIDOPHYTA

EQUISETALES

Genus ***PARACALAMITES*** Zalessky (1927) 1932

This generic name was first published in Zalessky's Atlas (1927) without a diagnosis. The species there figured were *Paracalamites decoratus* (Eichwald), *P. kutorgae* (Geinitz), and *P. striatus* (Schmalhausen), all of which had been originally described under *Calamites*. The name was subsequently published (Zalessky, 1932 : 112) in a paper on Upper Palaeozoic plants from Siberia, and the new species *Paracalamites sibiricus* was described at the same time. Even in this paper no formal generic diagnosis was given, but a few remarks were made on the reasons for founding a new genus, and seem just sufficient to validate it with *P. sibiricus* as the type species.

It was explained that the casts of the pith-cavities of *Calamites*-like stems and

rhizomes found in the Permian have the ridges of successive internodal segments in alignment instead of alternating in position and interdigitating at the nodes, as in true *Calamites*. In this respect they resemble the Lower Carboniferous genus *Asterocalamites*. Knowledge of their foliage, Zalessky thought, might eventually establish their identity with either *Phyllotheca*, *Schizoneura*, or *Lobatannularia*, but for the time being it seemed advisable to refer them to a new genus, *Paracalamites*. The foliage of one of these Permian species has, however, been described by Weigelt (1928 : 470, pl. 10, fig. 1), who founded a new species *Asterocalamites mansfeldicus* on specimens from the German Kupferschiefer. The characters of *Paracalamites*, in so far as they are known, may now be summarized as follows.

Stems and the casts of their pith-cavities with numerous narrow longitudinal ridges which are in alignment along successive internodal segments. Leaves lanceolate, not joined, arranged as star-shaped verticils on slender foliage shoots which arise in pairs and opposed at each node, and are directed upwards at an angle of about 45° ; number of leaves in each verticil small.

The genus resembles *Asterocalamites* in the alignment of the internodal ridges, but differs in the form of its leaves, which are not filiform and repeatedly forked.

Paracalamites kutorgai (Geinitz) Zalessky

(Pl. 37, fig. 1)

1880 *Calamites Kutorgai* Geinitz, p. 14, pl. 6, fig. 1.
1887 *Calamites Kutorgae* Geinitz : Schmalhausen, p. 33, pl. 1, figs. 7–17.
1927 *Paracalamites Kutorgae* (Geinitz) Zalessky, p. 36, pl. 1, fig. 1 ; pl. 44, figs. 3, 7.
1928 *Asterocalamites mansfeldicus* Weigelt, p. 470, pl. 10, figs. 1–4, 7–14.
1930 *Asterophyllites* (*Neocalamites*) *mansfeldicus* (Weigelt) Weigelt, p. 649.

Occurrence and material. Marl Slate of Fulwell Water Works, near Sunderland (one specimen) and of Cullercoats (two specimens), Hancock Museum.

Description. All three specimens are flattened stem fragments in shale. One specimen is 25 cm. long and 17 cm. wide and shows three nodes with internodes 45 mm. long. One node is shown enlarged in Pl. 37, fig. 1. The ribs on one internode are in alignment with those on the next. Another specimen is 25 mm. wide and shows internodes about 50 mm., 25 mm., 35 mm., and 25 mm. in length.

Discussion. Stems such as these agree with those of Lower Carboniferous *Asterocalamites*, but they match specimens from the German Kupferschiefer identifiable as *Paracalamites kutorgai*. It may be noted that Kirkby (1864) recorded " *Calamites arenaceus* ?" from the Upper Magnesian Limestone of Fulwell Hill, and that the specimen was catalogued by Howse (1890) under the name *Calamites wakei*. The specimen, which has not been traced, may have belonged to *P. kutorgai*.

Genus ***ANNULARIA*** Sternberg, 1821

Annularia ? sp.

(Text-fig. 4)

Occurrence and material. Marl Slate of Cullercoats, two specimens (Hancock Museum).

Description. Each specimen shows a whorl of what are taken to be 11 very small leaves, not more than 3 mm. long, round a circular space representing the node. No

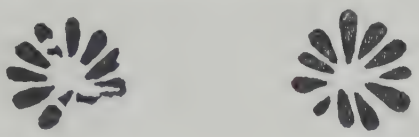


FIG. 4. *Annularia* ? sp. Marl Slate, Cullercoats. Hancock Museum. × 2.

midrib is, however, visible in these " leaves ". They occur in the same bed as *Paracalamites kutorgai* but differ in number and shape from the leaves of that species as described by Weigelt (1928).

PTERIDOSPERMAE

Genus ***CALLIPTERIS*** Brongniart, 1849

Callipteris martinsi (Kurtze) Zeiller

(Pl. 37, figs. 2, 5 ; Text-figs. 5, 6)

1839 *Alethopterin* (*sic*) *Martinsii* Germar MS.: Kurtze, p. 34, pl. 3, fig. 2.
1907 *Callipteris Martinsi* (Germar) : Gothan, pp. 1–4, figs. 1, 2. (See this for full synonymy.)
1928 *Callipteris Martinsi* (Germar) : Weigelt, p. 457, pl. 2, figs. 14, 15, 26 ; pl.7 ; pl. 35, figs. 7, 14, 21, 22, 26.

OCCURRENCE AND MATERIAL. Marl Slate of Kimberley, Watnall, and Cinderhill, near Nottingham ; several specimens (B.M.N.H.). Lower Marl of Magnesian Limestone Series, Doddington borehole (p. 300), depth 2,320 ft.; fragment (G.S.M.). Hilton

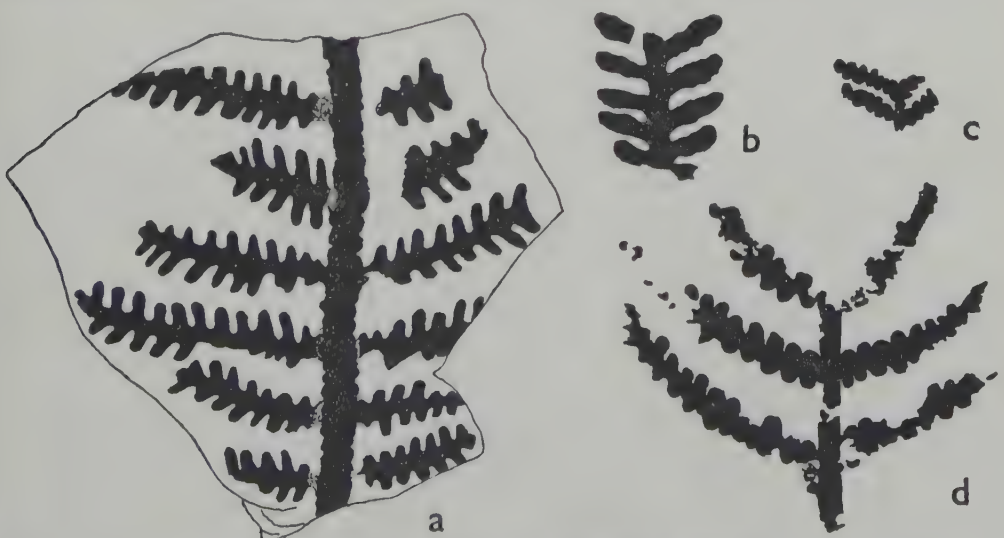


FIG. 5. *Callipteris martinsi* (Kurtze) Zeiller. (*a*), Marl Slate, Kimberley. British Museum (Natural History), no. V.5963*a* ; (*b*), Marl Slate, Kimberley. British Museum (Natural History), no. V.5963*b* ; (*c*), Hilton Plant Beds, Hilton. British Museum (Natural History), no. V.5975 ; (*d*), Main gypsum horizon, Acorn Bank quarry, near Temple Sowerby. Private collection. All × 1.

Plant Beds, Hilton and Belah Brook; several small shoots (B.M.N.H. and G.S.M.). Gypsum of Acorn Bank quarry, near Temple Sowerby (Text-fig. 5*d*, private coll.) and of Birkshead Mine (B.M.N.H.). Kirksanton Beds, Haverigg Haws borehole (p. 303); one fragment (G.S.M. no. TW 3846). Fragments were also identified in bulk-macerated cores from the borings at Sutton (p. 300), depth 1,085 ft., Lowdham (p. 301), depth 688 ft., and Farnsfield (p. 301); also from the Calverton Colliery shaft (p. 301).

Description. The best English specimens are from Kimberley; the largest is shown in Text-fig. 5*a*. The rachis has transverse ridges which may represent the pinnules known to be borne directly on it in German specimens, and the pinna

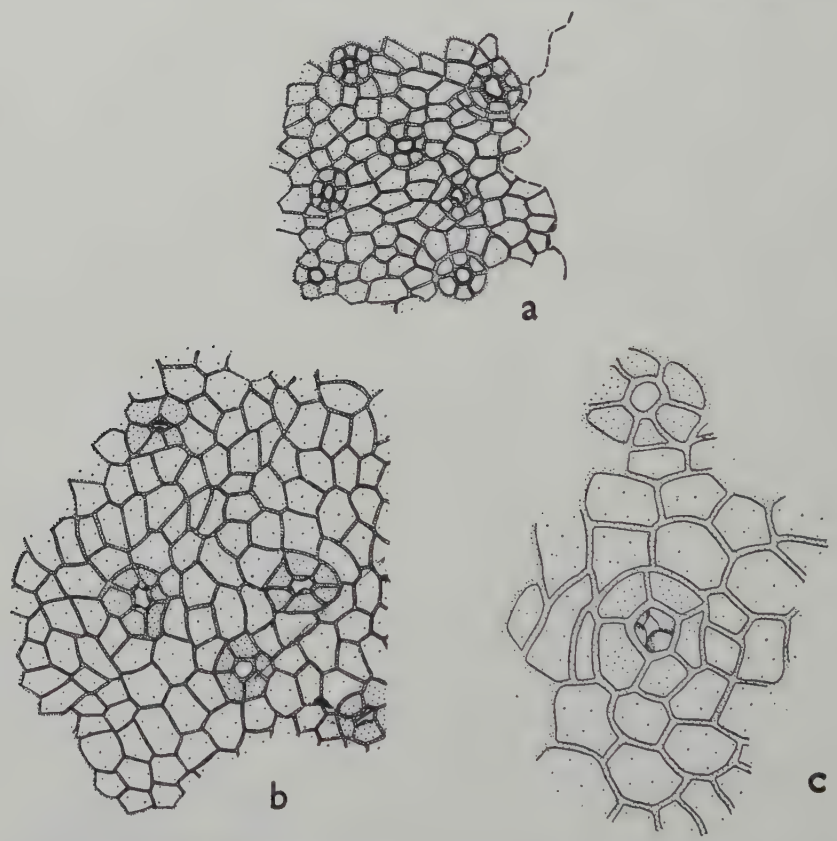


Fig. 6. *Callipteris martinsi* (Kurtze) Zeiller. Cuticle. (*a*), Marl Slate, Cinderhill. British Museum (Natural History), no. V.26971. × 110; (*b*), Marl Slate, Kimberley. British Museum (Natural History), no. V.35114. × 150; (*c*), Hilton Plant Beds, Hilton. British Museum (Natural History), no. V.35115. × 270.

rachises have similar but smaller ridges. Another Kimberley specimen (Pl. 37, fig. 5) has scars of unknown origin at some pinna bases; a previous worker who labelled this specimen regarded these as seed scars, but they may be the remains of pinnules; seeds of *C. martinsi* are unknown. Text-fig. 5*b* represents a specimen from the same locality in which the pinnules are lobed and relatively large. A few specimens from

this locality show a midrib and lateral veins. Small fragments with deeply lobed pinnules (Text-fig. 5*c*) are common at Hilton Beck and were recorded by Murchison & Harkness (1864) as *Alethopteris goepperti* (Münster), a synonym of *C. martinsi*. The specimen shown in Text-fig. 5*d* is remarkable for its preservation in gypsum.

Cuticle. Preparations were made from several specimens from Kimberley, Watnall, Cinderhill, and Hilton Beck. Text-fig. 6 and Pl. 37, fig. 2, show the cuticular structure. The ordinary epidermal cells of both cuticles are polygonal and do not show a median papilla, but the subsidiary cells often have a prominent papilla over the stomatal pit. The subsidiary cells number either five or six, the latter number appearing to be more usual on deeply lobed pinnules. The stomata are rare on one face of the leaf and frequent on the other.

Remarks. Although there are slight differences in their form, I consider that the numerous English fragments all belong to one species, as they have the same general type of cuticular structure. All of these forms can be matched (macroscopically) with German specimens included in *C. martinsi*, and they are, therefore, identified with that species. It is, however, surprising that there is a striking difference between their cuticle and that of an Upper Zechstein specimen figured by Gothan & Nagalhard (1922) and of another from the same locality, Frankenberg, figured by Florin (1931), which I examined in Stockholm ; for in the German specimens the epidermal cells have a clearly marked dark spot, representing a thickening of the cuticle. It may be that the presence of a papilla on epidermal cells is inconstant in *C. martinsi*, but it is also possible that some forms from the Zechstein once thought distinct species but now included in *C. martinsi* are, after all, distinct. Hence, the English specimens cannot be satisfactorily identified until the cuticles of many more German specimens have been studied.

Genus ***SPHENOPTERIS*** Brongniart, 1822

Sphenopteris bipinnata (Münster) Geinitz

(Pl. 37, fig. 6 ; Text-fig. 7)

1842 *Caulerpites bipinnatus* Münster, p. 102, pl. 14, fig. 3.
1846 *Sphenopteris dichotoma* Althaus, p. 30, pl. 4, fig. 1.
1928 *Sphenopteris dichotoma* Althaus : Weigelt, p. 448, pl. 8, figs. 3, 4.

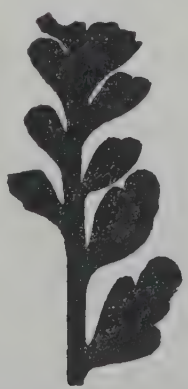


Fig. 7. *Sphenopteris bipinnata* (Münster) Geinitz. Hilton Plant Beds, Hilton. British Museum (Natural History), no. V.35117. × 1·5.

Occurrence and material. Hilton Plant Beds, Hilton Beck ; several fragments (B.M.N.H. and G.S.M.).

Description. In some of the fragments the leaves show their veins excellently, but in others the form alone is visible as the veins are not preserved in the coaly substance. Some small fragments resemble *S. patens* (Althaus), which Geinitz (1848) and Schenk (1864) but not some later authors have considered synonymous with *S. bipinnata*. No cuticle is preserved in the specimens examined.

Genus ***MIXONEURA*** Weiss, 1869

Mixoneura sp.

(Pl. 37, fig. 4)

1850 *Neuropteris Huttoniana* King, p. 6, pl. 1, fig. 4.

Occurrence and material. Marl Slate of Thrislington Gap, Durham. The type is preserved in University College, Galway. It is the only specimen seen, although King also recorded the species from Middridge, Brusselton, and East Thickley.

Remarks. The type specimen shows four pinnules on a single small piece of rock. This may have been broken and re-assembled and it is impossible to say how close they were originally. One pinnule is shown in Pl. 37, fig. 4 ; others seem to have been slightly broader or slightly longer. No further details are visible.

These fragments much resemble *Mixoneura neuropteroides* (Göppert), from the Lower Permian of Germany ; it is interesting that no *Mixoneura* is known to occur in the German Upper Permian.

Genus ***TAENIOPTERIS*** Brongniart, 1828

Taeniopteris eckardti Kurtze

(Pl. 37, figs. 3*a*, *b*)

1839 *Taeniopteris Eckardti* Germar MS., Kurtze, p. 34, pl. 3, fig. 1.
1851 *Taeniopteris Eckhardi* Germar : Ettingshausen, p. 99, pl. 13, figs. 2, 3.
1890 *Taeniopteris duffiana* Howse, p. 248 (*nom. nud.*).
1928 *Taeniopteris Eckardti* Germar : Weigelt, p. 461, pl. 2, fig. 21 ; pl. 9, figs. 7–18.
1930 *Taeniopteris eckardti* Germar : Weigelt, p. 647, figs. 13–16.
1933 *Taeniopteris eckardti* Germar : Schuster, p. 85, fig. 5 ; pl. 7, fig. 8.

Occurrence and material. Marl Slate of Middridge, Durham ; one specimen (Hancock Museum).

Description. The figures show the only English specimen, catalogued by Howse as *T. duffiana*. Its veins, clearly seen, are all parallel, forming an angle of 60° with the midrib, and number 8–9 to the centimetre. Its cuticle is not preserved. It agrees with *T. eckardti* from the Upper Permian of Germany.

Genus ***PSYGMOPHYLLUM*** Schimper, 1870

? ***Psygmophyllum cuneifolium*** (Kutorga) Schimper

(Pl. 40, figs. 14, 15 ; Text-figs. 8, 9)

1838 *Sphenopteris cuneifolia* Kutorga, p. 32, pl. 7, fig. 3.
1927 *Psygmophyllum cuneifolium* (Kutorga) : Zalessky, pl. 8, figs. 3, 4 ; pl. 9, figs. 2, 3 ; pl. 12, fig. 1 ; pl. 14, fig. 5 ; pl. 16, fig. 6 ; pl. 32, fig. 6 ; pl. 33, fig. 8 ; pl. 37, fig. 6.
1927 *Sphenopteris incerta* (Fischer) : Zalessky, p. 40, pl. 11, fig. 2.
1937 *Psygmophyllum cuneifolium* (Kutorga) : Zalessky, p. 64, text-fig. 27.

OCCURRENCE AND MATERIAL. Marl Slate of Middridge, two specimens (B.M.N.H.).
DESCRIPTION. Satisfactory photographic illustration of the specimens is not possible

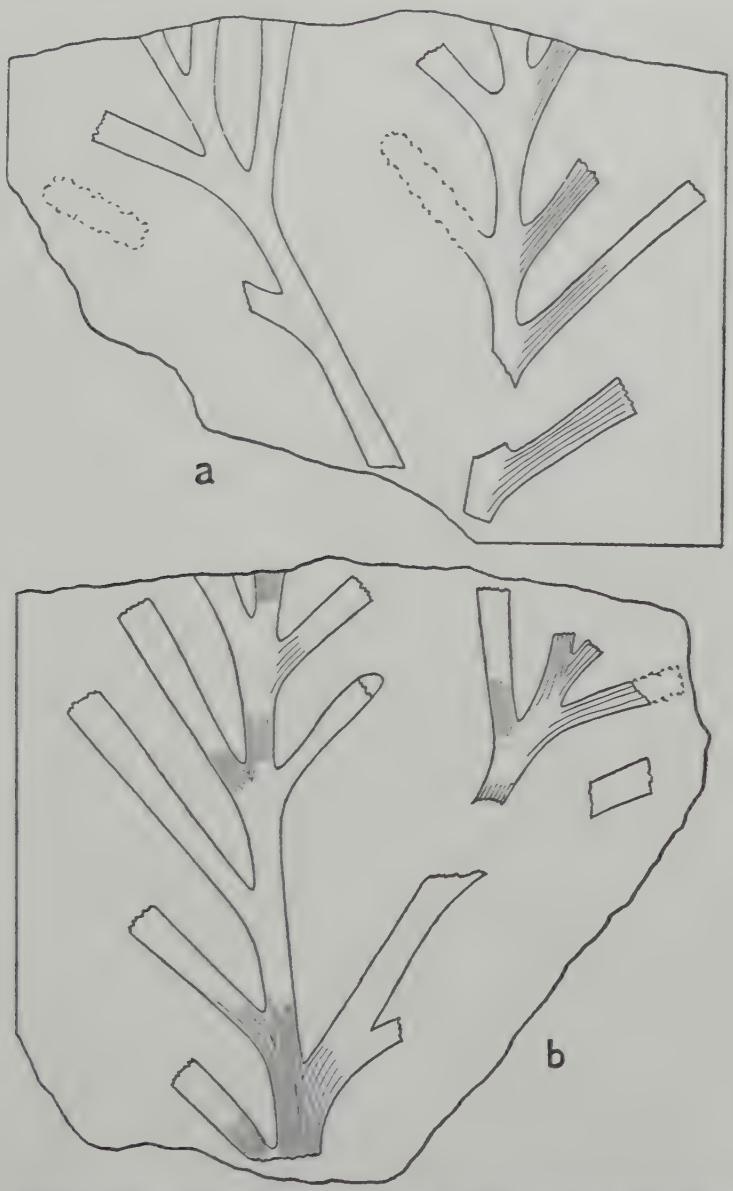


FIG. 8. ? *Psygmophyllum cuneifolium* (Kutorga) Schimper. Some remaining irregular patches of leaf substance are not indicated. Marl Slate, Middridge. British Museum (Natural History), nos. V.35131, V.35132. × 1.

as they are dirt-stained and the leaf substance, once complete, has peeled off in places. The form of the leaves, as shown in Text-figs. 8*a*, *b*, can, however, be made out. One

clearly shows forking of the leaf below and perhaps the beginning of a repeated forking at the apex. The other specimen indicates probable forking below (where broken away). Where the cuticle has disappeared the veins are visible as parallel longitudinal strands on the impressions of both rachis and pinnae.

Cuticle. The preparations were fragile and broke into small pieces. It was impossible to distinguish the two sides, but different kinds of epidermis were recognized along the veins and between them. Along strips assumed to be the veins the cells mostly form elongated polygons. Between the veins they are either isodiametric polygons, or polygons elongated in various directions often with one or more walls curved. At intervals on both types of epidermis are round scars most of which probably represent unicellular trichome bases although some are stomata. Six or more subsidiary cells form an imperfect ring round a circular pore in which the guard cell aperture is occasionally visible.

Discussion. These specimens resemble the one from the same locality (but apparently not from the same bed) described below (p. 321) as *Pseudoctenis middridgensis*. Unfortunately comparison of the cuticular structure is impossible as only very poor preparations are obtainable from that specimen. Although it is not impossible that future discoveries may prove their specific identity, the following points suggest

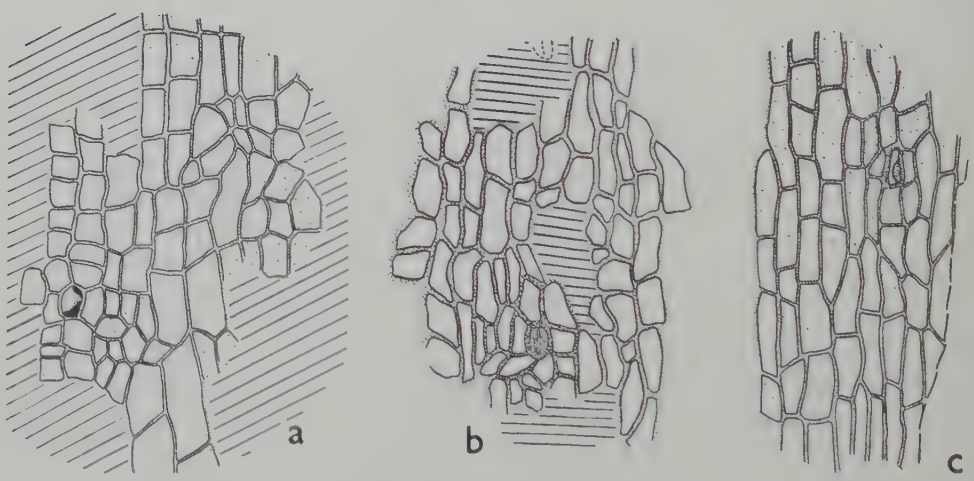


Fig. 9. ? *Psygmophyllum cuneifolium* (Kutorga) Schimper. Cuticle. Marl Slate, Middridge, British Museum (Natural History); (*a*), no. V.35133; (*b*), no. V.35134*a*; (*c*), no. V.35134*a*. All × 150.

that the two forms are distinct. In *P. middridgensis* the rachis is not known to fork; the pinnae are mostly narrower at the base and taper to a pointed apex; the veins are more delicate; and the cuticle appears to have been thinner. Most of the pinnae in the present specimens are incomplete owing to fracture of the rock, and their apparent truncation elsewhere may in some cases be due to breakage before fossilization. There is, however, no indication that a single one tapered to a point, and in one case the impression of what appears to have been the undamaged apex can just be seen to be bluntly rounded.

These specimens much resemble a figure of *Psygmophyllum cuneifolium* published

by Zalessky (1937) and are therefore referred with a query to that species. Previously described specimens are from the Permian of Russia, where the species is well represented although the cuticle has not been described. It is questionable whether *Psygmophyllum* is the best generic name for the species (cf. Arber, 1912), and it might be transferred to Zalessky's genus *Bardia*.

Genus ***SCHÜTZIA*** Geinitz, 1863

Schützia ? sp.

(Pl. 37, figs. 7–12)

Occurrence and material. Hilton Plant Beds of Hilton; several specimens, B.M.N.H. and G.S.M.

Remarks. The specimens illustrated look like the cup-like sporangial aggregates of *Schützia anomala* figured from the Lower Permian by Geinitz (1863), Göppert (1864), Schuster (1911) and Gothan (1937). It is not, however, possible to prove that they are of this nature. Compression has distorted many of them in various ways. Gothan thought that *S. anomala* belonged to the species *Sphenopteris germanica* Weiss, and the present specimens could belong to *S. bipinnata*, with which some were found associated.

Genus ***SPHENOBAIERA*** Florin, 1936

Sphenobaiera digitata (Brongniart) Florin

(Pl. 38, fig. 6; Text-figs. 10, 11)

1828 *Fucoides digitatus* Brongniart, p. 69, pl. 9, fig. 1.
1862 *Zonarites digitatus* (Brongn.) Geinitz, p. 336, pl. 26, figs. 1–3.
1876 *Baiera digitata* (Brongn.) Heer, p. 7, pl. 21, figs. 1, 2.
1880 *Schizopteris digitata* (Brongn.) Geinitz, p. 16, pl. 6, figs. 13, 14.
1928 *Baiera digitata* (Brongn.): Weigelt, p. 476, pl. 11, figs. 1–19; pl. 12, figs. 1–16.
1932 *Baiera digitata* (Brongn.): Weigelt, p. 148, pl. 4, figs. 1–3.
1936 *Sphenobaiera digitata* (Brongn.) Florin, p. 108.

Occurrence and material. Marl Slate of Middridge, Durham; 3 specimens (Hancock Museum). Hilton Plant Beds, Hilton Beck; several specimens (B.M. N.H. and author's coll.).

Description. Relatively good leaves from Middridge are shown in Text-fig. 10*a* and Pl. 38, fig. 6; unfortunately their cuticles are not preserved. Some recognizable although less perfect leaves (Text-fig. 10*b*) were found at Hilton and some of these retain their cuticles. The cuticle proved delicate; Text-fig. 11 shows parts of prepared fragments. The cuticle has the rather elongated cells and ring of subsidiary cells seen in many Ginkgoales. The stomatal pit is partly overhung by blunt papillae but the ordinary epidermal cells have none.

A curious structure found at Hilton (Pl. 38, fig. 4), looking like a capsule on a stalk, rather resembles the groups of microsporangia of the Rhaetic species *Baiera münsteriana* Heer figured by Schenk (1884 : 261, fig. 180*b*), but it is larger. The nature of the specimen was not determined, and although it was found in the same bed as leaves of *Sphenobaiera digitata* there is no proof that it belongs to that species.

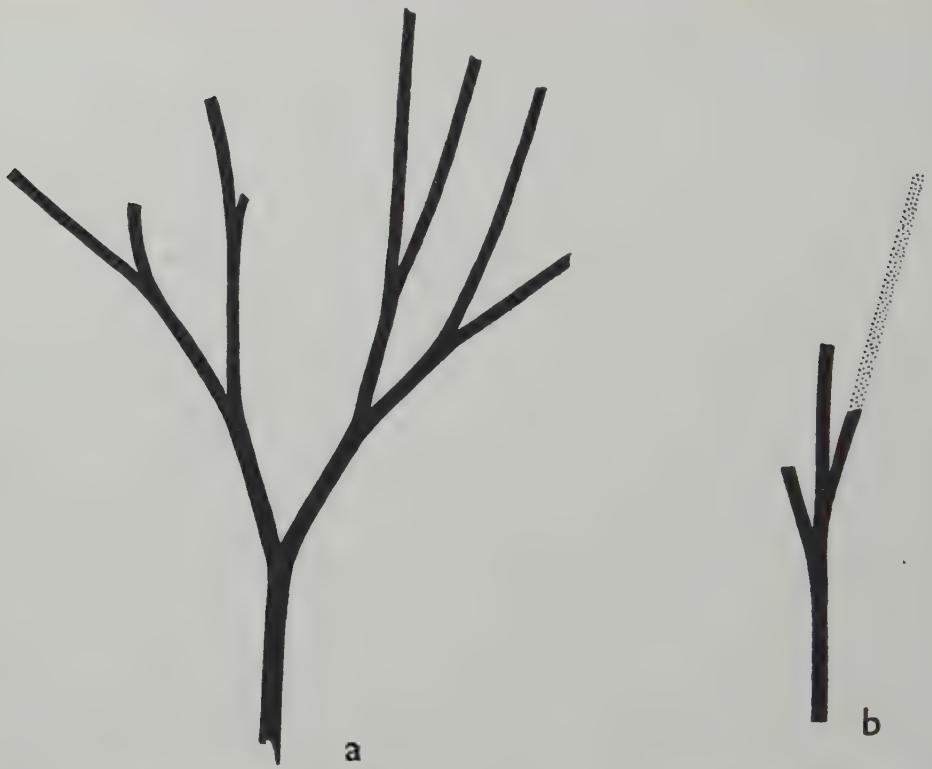


FIG. 10. *Sphenobaiera digitata* (Brongniart) Florin. (*a*), Marl Slate, Middridge. Hancock Museum; (*b*), Hilton Plant Beds, Hilton. British Museum (Natural History), no. V.35118. Both × 1.

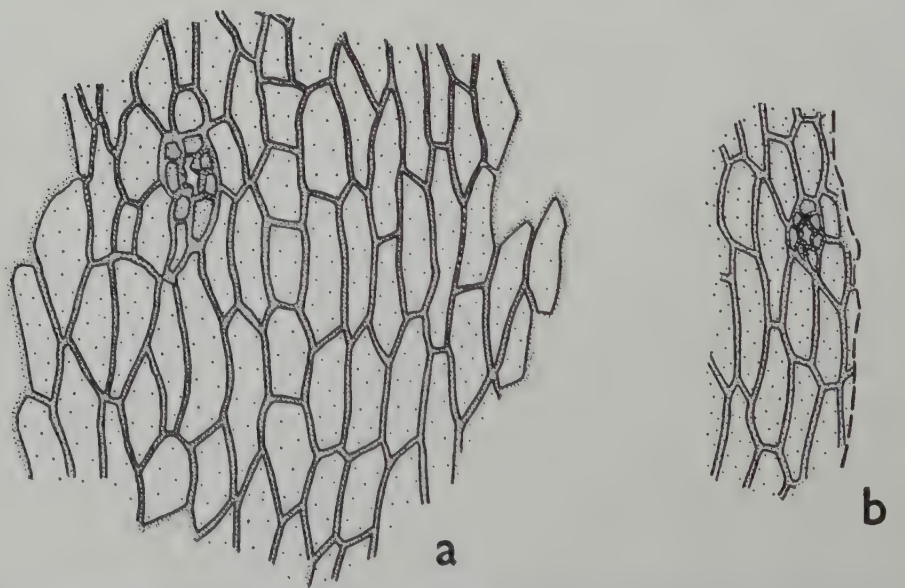


FIG. 11. *Sphenobaiera digitata* (Brongniart) Florin. Cuticle. Hilton Plant Beds, Hilton. (*a*), British Museum (Natural History), no. V.35135; (*b*), British Museum (Natural History), no. V.35136. Both × 200.

Genus *CORDAITES* Unger, 1850

cf. *Cordaites aequalis* (Göppert) Zalessky

(Pl. 38, fig. 3)

1845 *Noeggerathia aequalis* Göppert, p. 385, pl. 27, fig. 7.
1879 *Rhiptozamites Goepperti* Schmalhausen, pp. 32, 49, 81, pl. 4, figs. 2–4; pl. 7, figs. 23–27; pl. 15, figs. 1–11.
1912 *Cordaites aequalis* (Göppert) Zalessky, pl. 1, figs. 1, 3; pl. 2; pl. 3, figs. 1, 1*a*, 3, 3*a*, 4; pls. 4, 5; pl. 6, figs. 1–3; pl. 7, fig. 1.
1914 *Cordaites aequalis* (Göppert): Zalessky, p. 71, pl. 2, figs. 8, 8*a*, 10, 10*a*, 11–14, 6 *bis*, 6*a*.

Occurrence and material. Fackley Hill (p. 299), probably from basement beds of Magnesian Limestone Series; a leaf impression in cream-coloured limestone (G.S.M. no. 76680).

Description. The specimen (Pl. 38, fig. 3) is the impression of the upper part of a leaf with the base missing. It shows some obscure longitudinal ridges (visible in the figure) and also fine longitudinal cellular striations. There are impressions of similar but smaller bodies on the same piece of rock. No organic substance remains.

The specimen resembles leaves from the Russian Permian figured by Zalessky, although with such scanty material the identification is not very convincing. If it can be confirmed by the discovery of more material it will be interesting as *C. aequalis* is unknown in the German Zechstein.

Genus *PSEUDOCTENIS* Seward, 1911

Pseudoctenis middridgensis sp. nov.

(Pl. 38, fig. 5; Text-fig. 12)

Diagnosis. Leaf as a whole broadly lanceolate, typically about 18 cm. × 6 cm.; midrib straight, bearing pinnae laterally at an angle of 45°; pinnae typically 40 mm. × 4·5 mm., widely spaced, with lower margin strongly decurrent on rachis, contracted just above the base, and with upper part tapering from the middle to an acute point; base of pinna with two veins, each forking once or twice near the pinna base to give about 6, which continue without branching or anastomoses to the apex; cuticle of upper side of rachis with straight-walled elongated cells, that of other parts of leaf unknown.

Occurrence and material. Marl Slate of Middridge, Durham; holotype only (Hancock Museum).

Remarks. This specimen, catalogued by Howse (1890) under the *nomen nudum Ctenis permiana*, is probably the best preserved fossil plant ever found at Middridge. It is interpreted as consisting of two leaves on the same bedding plane, one lying across the other. Detached and disarranged pinnae surround the lower end of the rachis of the larger leaf. Parts of some pinnae are represented only by their impressions on which the venation is faintly visible, and the remaining parts by a thin carbonaceous film. The veins have no cross-connections. The cuticle is ill-preserved. A few frag-

FIG. 12. *Pseudoctenis middridgensis* sp. nov. Marl Slate, Middridge. Hancock Museum. × 1.

ments of cuticle from the upper side of the lamina were prepared, but the only ones showing any structure were from the rachis. These have elongated cells 20 μ wide in bands alternating with bands of less elongate cells very variable in size and shape. No stomata could be recognized. The ordinary epidermal cells have simple anticlinal walls which do not undulate, showing that the species does not belong to the Bennettitales.

This specimen resembles various Mesozoic leaves placed in *Pseudoctenis*, but in the absence of adequate knowledge of its cuticle its reference to that genus must be considered provisional, and it is also not definitely separable from *Pterophyllum*, though in typical species of that genus the pinnae arise rather above the lateral margins of the rachis. No comparable leaf is known from the Zechstein, but several from the Upper Carboniferous and Lower Permian have been referred to *Pterophyllum*. They differ in their more crowded, parallel-sided pinnae, which are almost at right angles to the rachis. The Permian leaf *Ctenis renaulti* Zalessky (1928 : 153) has broader and more crowded pinnae. *Plagiozamites* Zeiller (1894), from the Carboniferous and Permian, differs considerably in its crowded, broadly lanceolate pinnae.

CONIFERALES

Genus *ULLMANNIA* Göppert, 1850

Ullmannia bronni Göppert

(Pl. 38, figs. 1*a*,*b*, 2 ; Pl. 39, figs. 3, 4)

1828 *Cupressus Ullmanni* Bronn, p. 526, pl. 4, figs. 1–7, 9 (?), 10 (for figs. 8, 11 see *Strobilites bronni*).
1850 *Ullmannia Bronnii* Göppert, p. 185, pl. 20, figs. 1–19, 23*b* (for figs. 20–22, 23*a*, 24–26 see *Strobilites bronni*).
1862 *Ullmannia Bronni* Göppert : Geinitz, p. 154, pl. 30, fig. 2 ; pl. 31, figs. 22–27 (*non* figs. 11, 21, 28–30).
1876 *Ullmannia Bronnii* Göppert : Heer, p. 8, pl. 21, figs. 3–5.
1880 *Ullmannia Bronni* Göppert : Geinitz, p. 23, pl. 4, figs. 8–11, 14.
1884 *Ullmannia Bronnii* Göppert : Solms-Laubach, pp. 13–28, pl. 2, figs. 11–15.
1922 *Ullmannia Bronni* Göppert : Gothan & Nagalhard, p. 443, pl. 5, figs. 1, 2 ; pl. 6, fig. 1.
1928 *Ullmannia Bronni* Göppert : Weigelt, p. 564, pl. 35, figs. 1–5, 9.
1954 *Ullmannia Bronnii* Göppert : Florin, p. 2, pl. 2.

Occurrence and material. Marl Slate of Raisby Hill quarries (p. 298), one fine specimen (King's College, Newcastle-on-Tyne), and of Middridge, one specimen (G.S.M.). Isolated leaves (some as cuticle preparations) from Marl Slate of Cinderhill (p. 300) (B.M.N.H.) and of Calverton Colliery shaft (p. 301), depth 402–456 ft., (B.M. N.H.) ; from Lower Marl of Bentley Colliery (p. 300) (Wollaton Hall Mus.) and of Sutton borehole (p. 300), depth, 1,085 ft. (B.M.N.H.) ; from Lower Limestone or Lower Marl of Doddington borehole (p. 300), depths 2,300, 2,303 and 2,310 ft. (G.S.M.), and of Wellow borehole (p. 301) (B.M.N.H.) ; and from Hilton Plant Beds of Hilton (B.M.N.H.), Belah Brook, and Little Salkeld (Carlisle Mus.).

Description. The specimen from Raisby Hill (Pl. 38, figs. 1*a*, *b*) which is nearly 35 cm. long, consists of a main stem about 20 mm. wide and 20 cm. long which

divides into four secondary branches about 13 mm. wide, two of which ultimately bifurcate. Two of the secondary branches cross as they lie flattened on the bedding plane. The main stem and branches are densely covered with imbricating leaves, the impressions of which are clearly preserved. The leaves, have the broadly lanceolate form and bluntly angular extremity characteristic of *Ullmannia bronni*. Their median keel and longitudinal striations are visible in places. The leaves on the main stem are about 4·5 mm. wide and twice as long and there are about five to the width of the stem. The size of the leaves decreases towards the distal end of each branch, but their proportions remain the same. No cuticle is preserved.

There is a poorly preserved specimen of *U. bronni* from Middridge, but most specimens from that locality so labelled in museums belong to *U. frumentaria* or to *Hiltonia rivuli*. Many of the isolated leaves from the borings and colliery shafts have well-preserved cuticles. The preparations show characteristic dark bands with stomata in single files, and agree with the cuticle of *U. bronni* as figured by Gothan & Nagalhard (1922) and Florin (1944, 1954) from German and Belgian specimens, and as prepared by myself from German material.

Göppert was not justified in changing the trivial name of this species when founding the genus *Ullmannia*, but his name *bronni* is here retained in accordance with long-established usage.

Ullmannia frumentaria (Schlotheim) Göppert

(Pl. 39, figs. 1, 2 ; Text-figs. 13, 14)

1820 *Carpolithes frumentarius* Schlotheim, p. 419, pl. 27, fig. 1.
1828 *Fucoides selaginoides* Brongniart, p. 72, pl. 9, fig. 3.
1836 *Voltzia Phillipsii* Lindley & Hutton, p. 123, pl. 195.
1850 *Caulerpa ? selaginoides* (Brongn.) King, p. 3, pl. 1, figs. 3, 3*a*.
1922 *Ullmannia frumentaria* (Schloth.) : Gothan & Nagalhard, p. 445, pl. 5, fig. 3 ; pl. 6, figs. 3, 4. (See this for further literature.)
1928 *Archaeopodocarpus germanicus* Weigelt, pp. 485–553, pl. 2, figs. 24, 25 ; pl. 3, figs. 1, 4–6, 8 ; pl. 4, figs. 1, 2, 7, 11–13 ; pl. 6, figs. 3–12 ; ? pl. 13, figs. 7, 11, 13, 15, 17 ; pls. 23–38 (most figs.) ; pl. 31, figs. 1–3, 6, 7, 11.
1928 *Strobilifer frumentarius* (Schloth.) Weigelt, p. 553, pl. 30, figs. 1, 2, 11–17, 28–31, 34 ; pl. 35, figs. 10 *a*, *b*.
1944 *Ullmannia frumentaria* (Schloth.) : Florin, p. 447, pl. 169/170, figs. 10–12 ; p. 449, text-figs. 44*a*, *b* (microspores).
1944 *Ullmannia Bronnii* Göppert : Florin, p. 484, text-fig. 52 ; pl. 179/180, figs. 17–19 ; pl. 181/182, figs. 1, 2.

Occurrence and material. Marl Slate of Cullercoats, Middridge, Ferryhill, Thickley, Claxheugh, and Cinderhill ; numerous specimens in the chief collections studied. Hilton Plant Beds, Hilton Beck and Belah Brook, fragments of shoots and isolated leaves (B.M.N.H. and G.S.M.). Isolated leaves, some now as cuticle preparations, from Lower Marl of Sutton borehole (p. 300), depth 1,085 ft. (B.M.N.H.) ; from Lower Limestone or Marl of Doddington borehole (p. 300), depth 2,327 ft. (G.S.M.), and of Thoresby Colliery shaft (p. 301) (B.M.N.H.) ; and from Hilton Plant Beds of Little Salkeld (Carlisle Mus.).

Description. Text-fig. 13*c* shows a shoot apex with densely overlapping leaves ; Pl. 39, fig. 2, the lower part of a shoot with more widely spaced leaves ; and Text-

FIG. 13. *Ullmannia frumentaria* (Schlotheim) Göppert. (*a*), Marl Slate, Middridge. British Museum (Natural History), no. V.35130 ; (*b*), Hilton Plant Beds, Hilton. Geological Survey, no. 19075 ; (*c*), Marl Slate, Thickley. British Museum (Natural History), no. V.32390 ; (*d*), Marl Slate, Co. Durham. Dorman Memorial Museum, Middlesbrough. All × 1.

fig. 13*a* a shoot with rather short spreading leaves. It is noticeable that in some of the compressed shoots the leaves look less regular than in others. There are considerable differences in the size of the leaves on different shoots. Text-fig. 13*d* and Pl. 39, fig. 1 show fertile shoots similar to those from Germany described by Florin (1944). Unfortunately no details of the structure of the female cones can be made out. These fertile shoots and the majority of sterile ones from Durham are unsuitably preserved to give cuticle preparations. Rather poor preparations were obtained from a specimen from Cullercoats and good ones from isolated leaves from Thoresby Colliery shaft and from Hilton Beck. The details are like those of *U. bronni ;* the stomata are in single files along strips darker than those between the files. The struc-

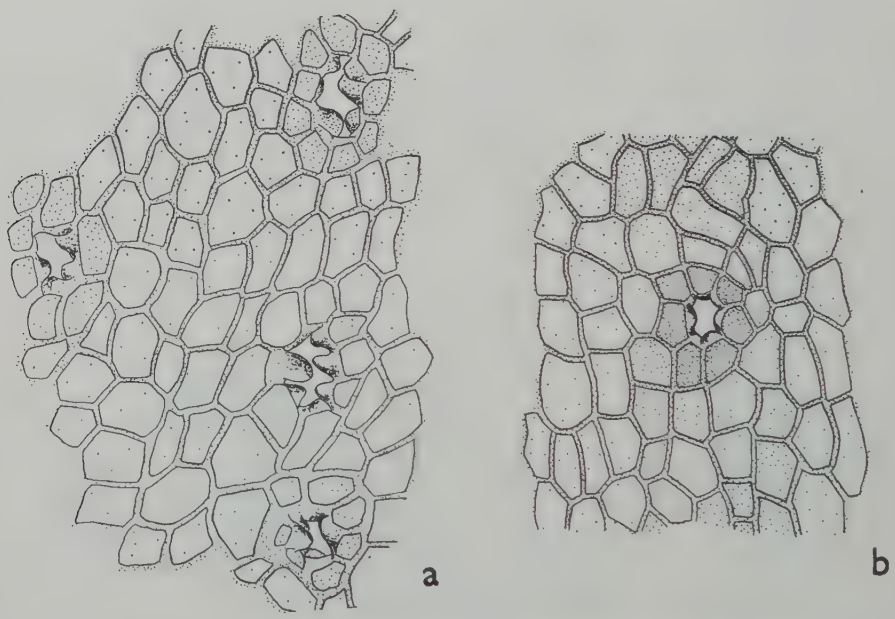


Fig. 14. *Ullmannia frumentaria* (Schlotheim) Göppert. Cuticle. (*a*), Marl Slate, Cullercoats. British Museum (Natural History), no. V.35137. × 150 ; (*b*), Magnesian Limestone Series, Thoresby Colliery shaft. British Museum (Natural History), no. V.35138. × 200.

ture agrees with that of the German specimens described by Gothan & Nagalhard (1922) and by Kräusel (1923).

The English specimens had previously been identified in museums as *U. frumentaria*, *U. selaginoides*, and *U. bronni*. The second was considered a synonym of *U. frumentaria* by Gothan & Nagalhard (1922), whose views are here accepted. The difference between *U. bronni* and *U. frumentaria* lies in the shape of the leaves. In *U. bronni* these are broadly lanceolate and mostly obtusely pointed, although some have rounded tips ; their length does not exceed $2\frac{1}{2}$ times their width. In *U. frumentaria* they are relatively and often absolutely longer and the apex is acute. There has, however, been some disagreement about the boundary between the two species.

By the criterion stated, most English specimens labelled as *U. bronni* belong to *U. frumentaria*.

The holotype of *Voltzia phillipsii* Lindley & Hutton, an early synonym of *U. frumentaria*, has not been traced ; it came from the Marl Slate of Whitley, Durham.

Genus ***PSEUDOVOLTZIA*** Florin, 1927

Pseudovoltzia liebeana (Geinitz) Florin

(Pl. 40, figs. 1, 4, 6 ; Text-figs. 15, 16)

1862 *Cyclopteris Liebeana* Geinitz, p. 140, pl. 26, figs. 4–6.
1880 *Voltzia liebeana* (Geinitz) Geinitz, p. 26, pl. 5, figs. 1–8, 10–25 (*non* figs. 9, 26).
1928 *Voltzia Liebeana* (Geinitz) : Weigelt, p. 565, pl. 5, fig. 4 ; pl. 16, figs. 4, 8, 9 ; pl. 31, figs. 4, 5, 8–10 ; pl. 32, figs. 1–29 ; pl. 33, figs. 1–19 ; pl. 34, figs. 1–11.
1929 *Voltzia Liebeana* (Geinitz) : Walton, p. 1, pl. 1 ; text-fig. 1.
1929 *Pseudovoltzia liebeana* (Geinitz) Florin, p. 257, pl. 4, fig. 10.
1944 *Pseudovoltzia Liebeana* (Geinitz) : Florin, p. 413, text-fig. 26*a* ; p. 479, text-figs. 50, 51 ; pl. 179/180, figs. 1–15.

Occurrence and material. Marl Slate of Thickley (B.M.N.H. and King's College, Newcastle-on-Tyne), of Ferryhill (G.S.M.), of Middridge ? (Hancock Museum), and of Kimberley (B.M.N.H.). Lower Marl, Sutton borehole (p. 300), depth 1,085 ft. (G.S.M.) and Markham Moor borehole (p. 300), depth 1,105 ft. (G.S.M.). Lower Magnesian Limestone, Wressell borehole (p. 300), depth 1,982–1,984 ft. (G.S.M.).

Fig. 15. *Pseudovoltzia liebeana* (Geinitz) Florin. Cone scales. (*a*), Marl Slate, Kimberley. British Museum (Natural History), no. V.35128 ; (*b*, *c*), Hilton Plant Beds, Hilton. Geological Survey, nos. 19073, 19074 ; (*d*), Hilton Plant Beds, Hilton. British Museum (Natural History), no. V.35119. All × 1·6.

Hilton Plant Beds, Hilton (B.M.N.H. and G.S.M.), Belah Brook, and Birkshead Mine.

Description. The English material consists of shoots, isolated leaves, and isolated cone scales. Typical shoots are shown in Pl. 40, figs. 1, 4 ; fig. 4 represents the largest seen. The leaves in all the specimens are elongated, parallel-sided, and rounded at the apex. Fig. 1 shows the short basal leaves produced when the bud first began growth ; as Florin pointed out, this is a character of the species (cf. Geinitz, 1880, pl. 5, fig. 1).

The cuticle has perished in the Durham specimens, but moderately good preparations were made from leaves from the Markham Moor borehole (Text-fig. 16). They look just like the figure given by Florin (1944 : 413) and some preparations I made from

German shoots. They are very similar to the cuticles of the two species of *Ullmannia* —so similar, indeed, that isolated fragments not showing the form of the whole leaf cannot be distinguished. There is, however, a possibility (which needs confirmation from further material) that in *Pseudovoltzia* the subsidiary and ordinary cells along the stomatal bands are less heavily cutinized ; that the ordinary epidermal cells are often

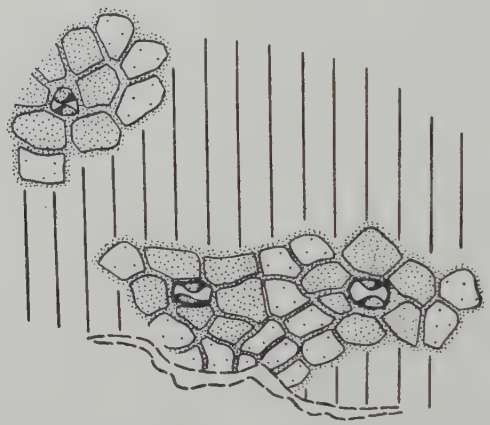


Fig. 16. *Pseudovoltzia liebeana* (Geinitz) Florin. Cuticle. Magnesian Limestone Series ; depth 1,293 ft., Markham Moor borehole. Geological Survey, no. PF623. × 200.

shorter ; that the subsidiary cells have a more regularly pentagonal shape ; and that the stomata are more often grouped in pairs or in threes. At present, however, the only reliable distinction between leaves of *Pseudovoltzia* and *Ullmannia* lies in their very different shape.

An excellent isolated cone scale from the Sutton borehole has been figured by Walton (1929) and Florin (1944, pl. 179/180, figs. 14, 15). Text-fig. 15 shows isolated cone-scales from Hilton and Kimberley preserved in carbonized form ; the lobes are strikingly varied.

The specimens from the Manchester Marls preserved in the Manchester Museum as the basis of records of this species by Geinitz (1890 : 549) and Roeder (1892 : 16) are indeterminate.

Genus ***HILTONIA*** Stoneley, 1956

Hiltonia rivuli Stoneley

1956 *Hiltonia rivuli* Stoneley, p. 714, text-figs. 1–4.

Occurrence. Marl Slate, Middridge, Thickley, and Kimberley. Lower Marl, Haughton Hall borehole (p. 300), depth 1,116 ft. ; and of Sutton borehole (p. 300), depth 1,085 ft. Lower Marl or Lower Limestone, Doddington borehole (p. 300), depths 2,310 and 2,330 ft. ; of Wellow borehole (p. 301) ; and of Farnsfield borehole (p. 301). Hilton Plant Beds, Hilton, Belah Brook, Birkshead Mine, and opencast mine near Kirkby Thore.

Genus *CONITES* Sternberg, 1823

Conites sp.

(Pl. 40, fig. 5)

Occurrence and material. Bulcote borehole (p. 301), depth 711 ft. (3 ft. 6 in. above base of Upper Permian beds); one specimen (G.S.M. no. 76681).

Description. The only specimen is shown in the figure. The lateral appendages seem irregularly spaced, but this is perhaps a result of compression of those originally above or below the bedding plane on which the specimen lies. Both main axis and appendages are longitudinally striated. There is nothing to show whether the expanded distal ends of the appendages bore pollen sacs or seeds. The specimen consists of crumbly carbonaceous matter and a fragment yielded no cuticle. The matrix contained no leaf or other plant remains throwing light on its identity.

Remarks. Nothing like this specimen has been previously described from the Permian. There are, however, a good many obscure cones from the Mesozoic which look something like it, and it is referred to *Conites* at the suggestion of Professor T. M. Harris.

Genus *STROBILITES* Lindley & Hutton, 1833

Strobilites bronni Solms-Laubach

(Pl. 40, figs. 7–11).

1850 *Ullmannia Bronnii* Göppert, p. 185 (in part), pl. 20, figs. 20 (?), 21, 22, 23*a*, 24–26.
1884 *Strobilites Bronnii* Solms-Laubach, p. 34, pl. 2, figs. 2, 3, 4 (?), 5–9, 16 (?), 17 (?), 18 (?), 19 (?).
1928 *Strobilites Bronni* Solms-Laubach: Weigelt, p. 474, pl. 10, fig. 5.
1930 *Strobilites bronni* Solms-Laubach: Weigelt, p. 644, pl. 1, fig. 2.
1931 " Rosetten von *Ullmannia bronni* ": Weigelt, p. 106, 108, text-figs. 3*b*, *c*.
1944 *Strobilites Bronni* Solms-Laubach: Florin, p. 447, pl. 169/170, figs. 13–22.

Occurrence and material. Marl Slate, Kimberley; several specimens (B.M. N.H.). Hilton Plant Beds, Hilton; several specimens (B.M.N.H., G.S.M.); also of Belah Brook.

Description. The specimens occur carbonized or as mere impressions. They show no fine details. The figures show the range of form. All can be matched among published figures of German specimens.

Remarks. There has been much doubt about the nature of these curious little fossils, specimens of which from the Upper Zechstein were described as " Sterngraupen " by Waldin (1778) and Ullmann (1802). Heer (1876) and Solms-Laubach (1884) doubted Göppert's assumption that they belonged to *Ullmannia*. Weigelt at first (1928) doubted but later (1931) accepted this view. Florin (1944) interpreted them as isolated segments of *Ullmannia* male cones. They vary so much in form that they may not all be of the same nature

Strobilites ludwigi (Weigelt)

1928 " Weibliche Blüte von *Archaeopodocarpus* ": Weigelt, p. 495, pl. 13, fig. 19.
1930 *Araucarites ludwigi* Weigelt, p. 660, text-fig. 39 ; ? also text-fig. 41 (p. 663).
1931 *Araucarites ludwigi* Weigelt : Weigelt, p. 107, 115, text-figs. 2, 12.

Occurrence and material. Hilton Plant Beds, Hilton ; one specimen (B.M. N.H., C. T. Trechmann Colln.).

Description. The specimen shows three rounded or bell-shaped groups of elongated leaf-like organs and closely resembles the fossil figured by Weigelt. The specimen is carbonized and no cuticle could be obtained from it ; no finer details are apparent.

Remarks. Weigelt first named his species *Araucarites*, but this generic name has been used by some authors for cones or cone scales which agree in structure with *Araucaria* (e.g. in having one seed on the upper surface of each scale), and nothing of the sort has been proved in this species. Weigelt abandoned his original view that it was the female inflorescence of " *Archaeopodocarpus* " (*Ullmannia*). The non-committal name *Strobilites* is here adopted for it.

Genus ***SAMAROPSIS*** Göppert, 1864

Samaropsis triangularis (Geinitz) Seward

(Pl. 40, figs. 2, 3)

1862 *Cardiocarpon triangulare* Geinitz, p. 145, pl. 31, figs. 11*, 12–15.
1880 *Ullmannia frumentaria* (Schloth.), " Fruchtschuppen mit Abdruck des Samens, früher *Cardiocarpon triangulare* ": Geinitz, p. 22, pl. 3, figs. 11–15.
1884 *Cardiocarpon triangulare* Geinitz : Solms-Laubach, p. 34, pl. 2, fig. 20.
1917 *Samaropsis triangularis* (Geinitz) Seward, p. 338.
1928 *Cyclocarpon triangulare* (Geinitz), " Fruchtschuppen, vielleicht aus Zapfen von *Strobilifer frumentarius* ": Weigelt, p. 560, pl. 30, figs. 23–26.

Occurrence and material. Marl Slate of Kimberley and Watnall ; several specimens (B.M.N.H.).

Remarks. The English specimens, which seem locally abundant, show the central part of the seed as a solid body surrounded by a flat membrane. The surface of the central part is slightly wrinkled. Geinitz (1880) and later Weigelt (1928) thought that this might be the seed of *Ullmannia frumentaria*, but Florin has found a different kind of seed in the seed-scale complex of that species.

UNIDENTIFIED CUTICLE TYPES

Bulk-macerated material from several boreholes and from the Hilton Plant Beds yielded a number of well-characterized cuticle types distinct from any of those prepared from identifiable plant remains. In some cases it was possible to ascertain the form of the complete leaf, but in others the material consisted only of small fragments. A set of descriptions and illustrations is available for consultation in the British Museum (Natural History), where the cuticle slides are also deposited. The identification of these cuticle types must await future research. More complete remains of the plant species to which the majority belong probably have yet to be

discovered and described, although a few of the new types may belong to described species the cuticular structure of which has not yet been investigated owing to lack of suitably preserved identifiable material.

NON-VEGETABLE STRUCTURES WHICH HAVE BEEN REGARDED AS PLANT REMAINS

Guilielmites permianus Geinitz

(Pl. 40, fig. 12)

1858 *Guilielmites permianus* Geinitz, p. 19, pl. 2, figs. 6–9.
1889 *Guilielmites permianus* Geinitz : Geinitz, p. 56 (English specimens).
1890 *Guilielmites permianus* Geinitz : Geinitz, p. 550 (English specimens).
1890*b* *Guilielmitis* (*sic*) *permianus* Geinitz : Roeder, p. 16 (English specimens).

Occurrence and material. Upper Permian Marl of Fallowfield, near Manchester ; specimens recorded by Geinitz and by Roeder are now in the Manchester Museum.

Remarks. First described from the German Rotliegende and originally regarded as a fructification of a palm related to the living *Guilielma*, *Guilielmites* is a peculiar structure now known from many geological formations. Authors who have discussed it include Weiss (1868 : 94 ; 1872 : 211), Carruthers (1871 : 446), Roemer (1880 : 246), Sterzel (1881 : 242), Hoffmann & Ryba (1899 : 102), Potonié (1921 : 16), Pruvost (1930 : 260) and Wood (1935). The best figures are those of Hoffmann & Ryba (1899, pl. 19, figs. 19, 20). Wood attributes such structures to the collapse under pressure of some body, such as a shell or plant fragment, which has been embedded in the sediment. As a result, a series of polished, striated surfaces came into existence owing to local slipping of the rock, which is always a compact, fine-grained shale.

Spongillopsis dyadica Geinitz

1889 *Spongillopsis dyadica* Geinitz, p. 56 (*non S. dyatica* Geinitz, 1862).
1890 *Spongillopsis dyadica* Geinitz : Geinitz, p. 550 (*non S. dyatica* Geinitz, 1862).

Occurrence and material. Upper Permian Marl of Stockport, near Manchester ; the specimen recorded by Geinitz, now in the Manchester Museum.

Remarks. It is doubtful if the short, irregularly curved, occasionally branching wrinkles which stand out on the surface of this specimen of red marl are of the same nature as Geinitz's original *S. dyatica*, itself problematical. The structures are undoubtedly of inorganic origin and the name can be expunged from the list of English Permian plants.

Palaeophycus insignis Geinitz

1861 " Cast of a laterally compressed tube . . . " Kirkby, p. 309.
1862 *Palaeophycus insignis* Geinitz, p. 131, pl. 24, fig. 4.
1890 *Palaeophycus insignis* Geinitz : Howse, pp. 237, 244.
1930 *Palaeophycus insignis* Geinitz : Weigelt, p. 645, text-fig. 1*a*, *b*.

Occurrence and material. Kirkby (1861) described specimens which must have

belonged to *P. insignis* from the Lower Magnesian Limestone of Hampole Stubbs, near Doncaster. Howse (1890) recorded *P. insignis* from the Lower Magnesian Limestone of Thickley and the Middle Magnesian Limestone of Tunstall Hill. The only specimen seen by the present writer is from Thickley and is in the Hancock Museum.

Remarks. The specimen from Thickley closely resembles that described by Geinitz, which came from the Dolomitic Zechstein near Gera and was a fragment, 40 mm. long and 7 mm. wide, of a smooth, solid, rod-like body elliptical in cross-section. He listed the species as an alga, but Weigelt (1930), who figured specimens from the Kupferschiefer of Ilmenau, thought that they were the borings of arthropods. There have been various theories as to the origin of other " species ", from different formations, described under Hall's genus *Palaeophycus* (Richter, 1927 : 198, 200 ; Schindewolf, 1928 : 39 ; Wilckens, 1947 : 47 ; Korn, 1932 : 17). No modern authorities consider them to be algae.

Chondrus binneyi King

(Pl. 40, fig. 13)

1850 *Chondrus* ? *Binneyi* King, p. 2, pl. 1, fig. 1.

Occurrence and material. Upper Permian Marl, just above Collyhurst Sandstone, of a river section at Newton, near Manchester (Binney, 1839 : 55 ; 1855 : 226). The holotype, formerly in the Binney Coll., has not been traced, but a topotype belonging to the Geological Survey has been examined. The specimen (G.S.M. no. Bc 4081) from the Ulleskelf Nurseries boring recorded as " cf. *Chondrus binneyi* King " (Edwards *et al.*, 1950 : 42) has also been examined.

Description. On the bedding planes of the red marl, in the topotype, are numerous irregularly scattered circular structures, each about 2 mm. in diameter and having the form of a raised ring with a central depression, or (as seen on the reverse surface) of a central boss surrounded by a moat-like depression. Between these structures each bedding plane is covered with sinuous fibrous markings, the general direction of which varies considerably. The structures are composed of the same material as the rest of the marl and carbonaceous matter is absent. They were regarded by King (1850) as " seed vessels " sessile on a " broad frond ", but there is little doubt they are of inorganic origin. They seem comparable to the " pit and mound " structures described by Kindle (1916), Shrock (1948 : 132) and other authors.

The Ulleskelf specimen consists of hard grey limestone with comparable structures, which, however, are more variable in size and often larger than in the topotype.

REFERENCES

Althaus, J. 1846. Ueber einige neue Pflanzen aus dem Kupferschiefer von Riechelsdorf. *Palaeontographica*, Stuttgart, **1** : 30–33, pls. 1, 4.

Arber, E. A. N. 1912. On *Psygmophyllum majus* sp. nov. from the Lower Carboniferous rocks of Newfoundland, together with a revision of the genus and remarks on its affinities. *Trans. Linn. Soc. Lond.* (*Bot.*), (2), **7** : 391–408, pls. 42–44.

Aveline, W. T. 1861. The geology of parts of Nottinghamshire and Derbyshire. *Mem. geol. Surv. U.K.*, Explan. ¼-Sheet 82 SE. 15 pp.

BEIN, G. 1932. Die Stellung des Richelsdorfer Gebirges zum Thüringer Walde und Rheinischen Schiefergebirge. *Z. dtsch. geol. Ges.*, Berlin, **84** : 786–829, pls. 25–27.

BINNEY, E. W. 1839. Sketch of the geology of Manchester and its vicinity. *Manchr. geol. Min. Soc. Trans.*, **1** : 35–66.

—— 1855. On the Permian beds of the North-West of England. *Mem. Manchr. lit. phil. Soc.* (2) **12** : 209–269.

BROCKBANK, W. 1892. On the Permians of the NW. of England. Discovery of two plant beds in the St. Bees Sandstone at Hilton, Westmorland. *Mem. Manchr. lit. phil. Soc.* (4) **5** : 66–76, pls. 2–4.

BRONGNIART, A. 1828. *Prodrome d'une histoire des végétaux fossiles.* viii + 223 pp. Paris.

BRONN, H. G. 1828. Untersuchung der versteinerten Kornähren und anderer Pflanzentheile, zu *Cupressus Ullmanni* gehörig, aus den Frankenberger Erz-Flözzen. *Z. Miner.*, Heidelberg (N.F.) **1828** (2) : 509–531, pl. 4.

CALVERT, R. 1884. *Notes on the geology and natural history of the County of Durham.* 184 pp. Bishop Auckland.

CARR, J. W. 1914. Permian. *In* J. W. Carr & H. H. Swinnerton. Report of an excursion to the Nottingham district. *Proc. Geol. Ass., Lond.*, **25** : 88–89.

CARRUTHERS, W. 1871. On some supposed vegetable fossils. *Quart. J. geol. Soc. Lond.*, **27** : 443–448, pl. 19.

DAKYNS, J. R., TIDDEMAN, R. H. & GOODCHILD, J. G. 1897. The geology of the country between Appleby, Ullswater and Haweswater. *Mem. geol. Surv. U.K.*, Explan. ¼-Sheet 102 SW. 110 pp.

DUNHAM, K. C. 1948. A contribution to the petrology of the Permian evaporite deposits of North-Eastern England. *Proc. Yorks. geol. Soc.*, **27** : 217–227, pl. 10.

DUNHAM, K. C. & ROSE, W. C. C. 1949. Permo-Triassic geology of South Cumberland and Furness. *Proc. Geol. Ass., Lond.*, **60** : 11–40.

ECCLES, J. 1871. On some sections of Permian strata near Kirkby Stephen. *Manchr. geol. Min. Soc. Trans.*, **10** : 30–37.

EDWARDS, W. 1951. The concealed coalfield of Yorkshire and Nottinghamshire. 3rd edit. *Mem. geol. Surv. U.K.* x + 285 pp., 5 pls.

EDWARDS, W., MITCHELL, G. H. & WHITEHEAD, T. H. 1950. Geology of the district north and east of Leeds. *Mem. geol. Surv. U.K.*, Explan. Sheet 70. 93 pp.

ETTINGSHAUSEN, C. VON. 1851. Beiträge zur Flora der Vorwelt. *Naturw. Abh.*, Wien (Haidinger), **4**, 1 : 65–100, pls. 8–13.

FLORIN, R. 1929. Über einige Algen und Koniferen aus dem mittleren und oberen Zechstein. *Senckenbergiana*, Frankfurt a.M., **11** : 241–266, pls. 1–5.

—— 1931. Untersuchungen zur Stammesgeschichte der Coniferales und Cordaitales. Erster Teil : Morphologie und Epidermisstruktur der Assimilationsorgane bei den rezenten Koniferen. *K. svenska VetenskAkad. Handl.*, Stockholm (3) **10**, 1 : 588 pp., 58 pls.

—— 1936. Die fossilen Ginkgophyten von Franz-Joseph-Land, nebst Erörterungen über vermeintliche Cordaitales mesozoischen Alters. *Palaeontographica*, Stuttgart, **81**, B : 71–173, pls. 11–42.

—— 1938–45. Die Koniferen des Oberkarbons und des unteren Perms. *Palaeontographica*, Stuttgart, **85**, B. 729 pp., 186 pls.

—— 1954. Note on *Ullmannia* from the Upper Permian formation of north-eastern Belgium. *Ass. Étude Paléont. Stratigr. houillères, Publ.*, **18**. 6 pp., 2 pls.

GEINITZ, H. B. 1848. *Die Versteinerungen des deutschen Zechsteingebirges.* 26 pp., 8 pls. Dresden & Leipzig.

—— 1861–62. *Dyas, oder die Zechsteinformation und das Rothliegende.* xviii + 130 pp., pls. 1–23 (1861) ; viii + 131–342 pp., pls. 24–42 (1862). Leipzig.

—— 1863. Über zwei neue dyadischen Pflanzen. *Neues Jb. Min. Geol. Paläont.*, Stuttgart, **1863** : 525–530, pls. 6, 7.

—— 1880. Nachtraege zur Dyas, I. *Mitt. min.-geol. praehist. Mus. Dresden*, **3**. 43 pp., 7 pls.

—— 1889. Ueber die roten und bunten Mergel der oberen Dyas bei Manchester. *S.B. Isis Dresden*, **1889** : 48–57.

GEINITZ, H. B. 1890. On the red and variegated marls of the Upper Dyas, near Manchester. *Manchr. geol. Min. Soc. Trans.*, **20** : 537–554.

GIBSON, W. & OTHERS. 1908. The geology of the southern part of the Derbyshire and Nottinghamshire coalfield. *Mem. geol. Surv. U.K.*, Explan. Sheet 125. 199 pp.

GIBSON, W. & WEDD. C. B. 1913. The geology of the northern part of the Derbyshire coalfield and bordering tracts. *Mem. geol. Surv. U.K.* viii + 186 pp., 6 pls.

GOODCHILD, J. G. 1889. Excursion to North-West Cumberland and Edenside. Appleby, Helton Beck and Roman Fell. *Proc. Geol. Ass., Lond.*, **11** : xciv–xcvi.

—— 1889*a*. An outline of the geological history of the Eden Valley or Edenside. *Proc. Geol. Ass., Lond.*, **11** : 258–284.

GÖPPERT, H. R. 1845. (Descriptions of fossil plants.) *In* P. de Tchihatcheff, *Voyage scientifique dans l'Altaï oriental* : 379–392, pls. 25–35. Paris.

—— 1850. *Monographie der fossilen Coniferen.* 286 + 73 pp., 58 pls. Leiden.

—— 1864–65. Die fossile Flora der permischen Formation. *Palaeontographica*, Stuttgart, **12**. 316 pp., 64 pls.

GOTHAN, W. 1907. *Callipteris Martinsi. In* Potonié, H. *Abbildungen und Beschreibungen fossiler Pflanzen-Reste* (*K. preuss. geol. Landesanst.*), **5**, 96, 4 pp., 2 figs. Berlin.

—— 1937. Zwei interessante Funde von Rotliegendpflanzen in Thüringen. *Jb. preuss. geol. Landesanst.*, Berlin, **57** : 507–513, pls. 27–29.

GOTHAN, W. & NAGALHARD, K. 1922. Kupferschieferpflanzen aus dem niederrheinischen Zechstein. *Jb. preuss. geol. Landesanst.*, Berlin, **42** : 440–460, pls. 5–7.

HANCOCK, A. & HOWSE, R. 1870. On a new Labyrinthodont Amphibian from the Magnesian Limestone of Middridge, Durham. *Quart. J. geol. Soc. Lond.*, **26** : 556–564, pl. 38.

HARKNESS, R. 1862. On the Sandstones and their associated Deposits in the Vale of the Eden, the Cumberland Plain, and the South-east of Dumfriesshire. *Quart. J. geol. Soc. Lond.*, **18** : 205–218.

HEER, O. 1876. Ueber permischen Pflanzen von Fünfkirchen in Ungarn. *Mitt. Jb. ung. geol. Anst.*, Budapest, **5** : 1–18, pls. 21–24.

HICKLING, G. 1931. The Summer Field Meeting, 1931, in Northumberland and Durham. *Proc. geol. Ass., Lond.* **42** : 378–385.

HICKLING, G., ROBERTSON, T. & OTHERS. 1948. North-East Coast. *Internat. geol. Congr.*, 18 *Sess., Excursion Guide* **C 9**. 26 pp. London.

HOFFMANN, A. & RYBA, F. 1899. *Leitpflanzen der palaeozoischen Steinkohlenablagerungen in Mittel-Europa.* 108 pp., atlas, 20 pls. Prag.

HOWSE, R. 1890. Catalogue of the local fossils in the Museum of the Natural History Society. *Nat. Hist. Trans. Newcastle*, **10** : 227–288.

KINDLE, E. M. 1916. Small pit and mound structures developed during sedimentation. *Geol. Mag.*, London, **6** : 542–547, pl. 13.

KING, W. 1850. *A Monograph of the Permian fossils of England.* xxxviii + 258 pp., 28 pls. [*Mon. Pal. Soc.*, London].

KIRKBY, J. W. 1861. On the Permian rocks of south Yorkshire ; and on their palaeontological relations. *Quart. J. geol. Soc. Lond.*, **17** : 287–325, pl. 7.

—— 1862. On the remains of fish and plants from the Upper Limestone of the Permian series of Durham. *Ann. Mag. nat. Hist.*, London, **3** : 267–269.

—— 1864. On some remains of fish and plants from the " Upper Limestone " of the Permian series of Durham. *Quart. J. geol. Soc. Lond.*, **20** : 345–358, pl. 18.

—— 1864*a*. On some fossils from the Lower Magnesian Limestone of Sunderland. *Trans. Tyneside Nat. Field Club*, **6** : 212–220.

—— 1867. On some remains of fish and plants from the " Upper Limestone " of the Permian series of Durham. *Nat. Hist. Trans. Newcastle*, **1** : 64–83, pl. 9.

—— 1867*a*. On the Fossils of the Marl-slate and Lower Magnesian Limestone (Durham, No. 11). *Nat. Hist. Trans. Newcastle*, **1** : 184–200.

KORN, H. 1932. Entgasungsspuren in Sedimenten. *Chem. d. Erde*, Jena, **7** : 1–23.

KRÄUSEL, R. 1923. Paläobotanische Notizen. VII. Über Papillenbildung an den Spaltöffnungen einiger fossiler Gymnospermen. *Senckenbergiana*, Frankfurt a.M., **5** : 81–96, pls. 3, 4.

KURTZE, G. A. 1839. *Commentatio de petrefactis quae in schisto bituminose Mansfeldensi reperiuntiur.* 38 pp., 3 pls. Halae.

KUTORGA, S. 1838. *Beitrag zur Kenntniss der organischen Ueberreste des Kupfersandsteins am westlichen Abhange des Urals.* 38 pp., 7 pls. St. Petersburg.

LAMPLUGH, G. W. & GIBSON, W. 1910. The geology of the country around Nottingham. *Mem. geol. Surv. U.K.* vi + 72 pp.

LINDLEY, J. & HUTTON, W. 1835–37. *The Fossil Flora of Great Britain*, **3**. 205 pp., pls. 157–230. London.

MÜNSTER, G. 1842. Ueber die Fucoiden des Kupferschiefers. *Beitr. Petrefacten-Kunde*, Bayreuth, **5** : 100–102, pls. 14, 15.

MURCHISON, R. I. & HARKNESS, R. 1864. On the Permian rocks of the north-west of England, and their extension into Scotland. *Quart. J. geol. Soc. Lond.*, **20** : 144–165.

NAUMANN, E. 1934. Zur Stratigraphie und Lagerung des Königseer Zechsteins. *Jb. preuss. geol. Landesanst.*, Berlin, **54** : 194–203, pls. 13*a*, *b*.

POTONIÉ, H. 1921. *Lehrbuch der Paläobotanik.* Edit. 2. 537 pp., 326 figs. Berlin.

PRAGER, H. 1932. Die Perm-Trias-Grenze nördlich des Kellerwaldes. *Z. dtsch. geol. Ges.*, Berlin, **84** : 317–360, pl. 9.

PRUVOST, P. 1930. La faune continentale du terrain houiller de la Belgique. *Mém. Mus. Hist. nat. Belg.*, Bruxelles, **44** : 105–282, pls. 1–14.

REMY, W. 1953. Untersuchungen über einige Fruktifikationen von Farnen und Pteridospermen aus dem mitteleuropäischen Karbon und Perm. *Abh. dtsch. Akad. Wiss. Berl.*, **1952**, 2 : 38 pp., 7 pls.

RICHTER, R. 1927. Die fossilen Fährten und Bauten der Würmer. *Paläont. Z.*, Berlin, **9**: 193–235, pls. 1–4.

ROEDER, C. 1890. Some newly discovered species in the Upper Permian deposits of Manchester. *Manchr geol. Min. Soc. Trans.*, **20** : 535–537.

—— 1890*a*. Notes on the Upper Permians, etc., at Fallowfield, lately laid open. *Manchr geol. Min. Soc. Trans.*, **20** : 615–627.

—— 1890*b*. Description of fossils found in the Permian Upper Series, at Fallowfield. *Manchr geol. Min. Soc. Trans.*, **21** : 13–16.

—— 1892. Notes on the Permians and superficial beds at Fallowfield. *Manchr geol. Min. Soc. Trans.*, **21** : 104–113.

ROEMER, F. 1880. Systematische Aufzählung und Beschreibung der bezeichnenden paläozoischen Fossilien. I. Pflanzen. *Lethaea geognostica*, I, *Lethaea palaeozoica*, **1** : 115–258. Stuttgart.

SCHENK, A. 1864. Beiträge zur Flora der Vorwelt. *Palaeontographica*, Stuttgart, **11** : 296–308, pls. 46–49.

—— 1884–90. Completion of W. P. Schimper, Palaeophytologie. *Handb. Palaeont.* (edit. K. A. Zittel), **2** : 233–958. München & Leipzig.

SCHINDEWOLF, O. H. 1928. Studien aus dem Marburger Buntsandstein, III–VII. *Senckenbergiana*, Frankfurt a.M., **10** : 16–54.

SCHLOTHEIM, E. F. VON. 1820. *Die Petrefactenkunde.* lxii + 437 pp., atlas 29 pls. Gotha.

SCHMALHAUSEN, J. 1879. Beiträge zur Jura-Flora Russlands. *Mém. Acad. Sci. St-Pétersb.* (*Sci. math., phys., nat.*), **27**, 4 : 96 pp., 16 pls.

—— 1887. Die Pflanzenreste der artinskischen und permischen Ablagerungen im Osten des europäischen Russlands. *Mém. Com. géol., St-Pétersb.*, **2**, 4 : 1–42, pls. 1–7.

SCHUSTER, A. 1933. Oberrotliegendes und Zechstein in Sachsen. *Abh. sächs. geol. Landesamts*, Leipzig, **13** : 1–85, pls. 1–8.

SCHUSTER, J. 1911. Über die Fruktifikation von *Schuetzia anomala*. *S.B. Akad. Wiss. Wien*, **120**, 1 : 1125–1134, pls. 1, 2.

SEDGWICK, A. 1829. On the geological relations and the internal structure of the Magnesian Limestone, and the lower portions of the New Red Sandstone series in their range through Nottinghamshire, Derbyshire, Yorkshire, and Durham, to the southern extremity of Northumberland. *Trans. geol. Soc. Lond.*, **2**, 3 : 37–124.

SEWARD, A. C. 1912. Mesozoic plants from Afghanistan and Afghan-Turkistan. *Palaeont. indica*, Calcutta (N.S.) **4**, 4 : 1–57, pls. 1–7.

—— 1917. *Fossil Plants*, **3**. xviii + 656 pp. 253 figs., London.

SHROCK, R. R. 1948. *Sequence in layered rocks*. 507 pp. New York.

SIMPSON, S. 1957. On the trace-fossil *Chondrites*. *Quart. J. geol. Soc. Lond.*, **112** : 475–499, pls. 21–24.

SMITH, B. 1913. The geology of the Nottingham district. *Proc. geol. Ass., Lond.*, **24** : 205–240, pls. 38–41.

—— 1919. Iron ores : haematites of West Cumberland, Lancashire and the Lake District. *Mem. geol. Surv. U.K., Special Repts. min. Resources*, **8**. 182 pp.

SOLMS-LAUBACH, H. 1884. Die Coniferenformen des deutschen Kupferschiefers und Zechsteins. *Paläont. Abh.*, Berlin, **2** : 81–116, pls. 12–14.

STERZEL, J. T. 1881. Paläontologischer Charakter der oberen Steinkohlenformation und des Rotliegenden im Erzgebirgischen Becken. *Ber. naturw. Ges. Chemnitz*, **7** : 155–270.

STONELEY, H. M. M. 1956. *Hiltonia*, a new plant genus from the Upper Permian of England. *Ann. Mag. nat. Hist.*, London (12) **9** : 713–720, 5 figs.

TRECHMANN, C. T. 1921. Some remarkably preserved brachiopods from the Lower Magnesian Limestone of Durham. *Geol. Mag.*, London, **58** : 538–543, pl. 12.

—— 1925. The Permian formation in Durham. *Proc. geol. Ass. Lond.*, **36** : 135–145.

—— 1931. Contributions to the geology of Northumberland and Durham. V. The Permian. *Proc. geol. Ass., Lond.*, **42** : 246–252.

—— 1942. Borings in the Permian and Coal Measures around Hartlepool. *Proc. Yorks. geol. Soc.*, **24** : 313–327.

—— 1952. (Contribution to discussion of paper by L. R. Raymond on exploration for potash in NE. Yorkshire.) *Quart. J. geol. Soc. Lond.*, **108** : 307.

TROTTER, F. M. & HOLLINGWORTH, S. E. 1932. The geology of the Brampton district. *Mem. geol. Surv. U.K.*, Explan. Sheet 18. 223 pp.

ULLMANN, J. C. 1802. *Mineralogische Beobachtungen*, **1**. 160 pp., 4 pls. Marburg.

WALDIN, J. G. 1778. *Die Frankenberger-Versteinerungen, nebst ihren Ursprunge*. 32 pp., 1 pl. Marburg.

WALTON, J. 1929. On the structure of a Palaeozoic Cone-Scale and the evidence it furnishes of the primitive nature of the Double Cone-Scale in the Conifers. *Mem. Manchr lit. phil. Soc.*, **73** : 1–6, pl. 1.

WEIGELT, J. 1928. Die Pflanzenreste des mitteldeutschen Kupferschiefers und ihre Einschaltung ins Sediment. *Fortschr. Geol.*, Berlin, **6** : 395–592, 35 pls.

—— 1930. Neue Pflanzenfunde aus dem Mansfelder Kupferschiefer. *Leopoldina*, Halle, **6** : 643–668, 2 pls.

—— 1931. Neue Pflanzenfunde aus dem Mansfelder Kupferschiefer. *Z. Naturw.*, Leipzig, **89** : 104–125, 19 figs.

—— 1932. Über die Fruktifikationsverhältnisse von Kupferschiefer-Coniferen und andere neue Pflanzenfunde. *Paläont. Z.*, Berlin, **14** : 137–149, pls. 3, 4.

WEISS, C. E. 1868. Begrundung von fünf geognostischen Abtheilungen in den Steinkohlenführenden Schichten des Saar-Rheingebirges. *Verh. naturh. Ver. preuss. Rheinl.*, Bonn, **25** : 63–134.

—— 1869–72. *Fossile Flora der jüngsten Steinkohlenformation und des Rothliegenden im Saar-Rhein-Gebiete*. 250 pp., 20 pls. Bonn.

WILCKENS, O. 1947. Paläontologische und geologische Ergebnisse der Reise von Kohl-Larsen (1928–29) nach Süd-Georgien. *Abh. senckenb. naturf. Ges.*, Frankfurt a.M., **474** : 1–66, pls. 1–9.

WILSON, E. 1876. On the Permians of the North-East of England (at their southern margin) and their relations to the under- and overlying formations. *Quart. J. geol. Soc. Lond.*, **32** : 533–537.

—— 1881. The Permian formation in the north-east of England, with special reference to the physical conditions under which these rocks were formed. *Mid. Nat.*, Birmingham, **4** : 97–101, pl. 6 ; 121–124, pl. 7 ; 187–191 ; 201–208.

WOOD, A. 1935. The origin of the structure known as *Guilielmites*. *Geol. Mag.*, London, **72** : 241–245, pl. 10.

WOOLACOTT, D. 1898. An explanation of the Claxheugh section (Co. Durham). *Quart. J. geol. Soc. Lond.*, **54** : 14.

—— 1903. An explanation of the Claxheugh section (Co. Durham). *Nat. Hist. Trans. Newcastle*, **14** : 211–221.

—— 1912. The stratigraphy and tectonics of the Permian of Durham (northern area). *Proc. Univ. Durham phil. Soc.*, **4** : 241–313.

ZALESSKY, M. D. 1912. Sur le *Cordaites aequalis* Göppert sp. de Sibérie et sur son identité avec la *Noeggerathiopsis hislopi* Bunbury sp. de la flore du Gondwana. *Mém. Com. géol., St.-Pétersb.* (N.S.) **86** : 1–43, pls. 1–7.

—— 1914. Flore gondwanienne du bassin de la Petchora. *Bull. Soc. oural. Sci. nat.*, Ekaterinburg, **33** : 55–85, pls. 1–4.

—— 1927. Flore permienne des limites ouraliennes de l'Angaride. *Mém. Com. géol., Léningr.* (N.S.) **176** : 1–52, pls. 1–46.

—— 1928. Sur l'extension du continent de l'Angaride et premières données sur la flore de ses limites oussouriennes. *Ann. Soc. géol. Nord*, Lille, **53** : 118–138.

—— 1932. Observations sur les végétaux nouveaux paléozoiques de Sibérie. *Ann. Soc. géol. Nord*, Lille, **57** : 111–134.

—— 1937. Sur la distinction de l'étage Bardien dans le Permien de l'Oural et sur sa flore fossile. *Probl. Palaeont.*, Moscow, **2–3** : 31–101.

ZEILLER, R. 1894. Notes sur la flore des couches permiennes de Trienbach (Alsace). *Bull. Soc. géol. Fr.*, Paris (3) **22** : 163–182, pls. 8, 9.

PLATE 36

FIG. 1. *Algites sternbergianus* (King). Fine filaments are visible on the curved axis. Lower Magnesian Limestone, Westoe, South Shields. Geological Survey, no. 90165. × 1.

FIG. 2. Same species, formation, and locality. Group of axes. Geological Survey, no. 90164. × 1.

FIG. 3. *Piaea anglica* sp. nov. Group of axes. Magnesian Limestone series, depth 1,140 ft., Markham Moor borehole, near East Retford. Geological Survey, no. 76607. × 2 approx.

FIG. 4. *Calathella dictyonemoides* sp. nov. Magnesian Limestone series, depth 1,056 ft., Markham Moor borehole, near East Retford. Geological Survey, no. 76608. × 1.

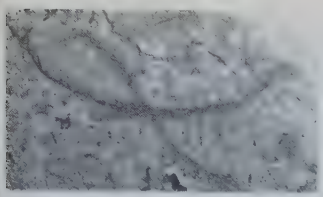
FIG. 5. *Algites sternbergianus* (King). Brush of filaments. Same formation and locality as Figs. 1, 2. Geological Survey, no. 49956. × 2·2.

FIG. 6. ? *Tubulites permianus* (King). Bunched tubes. Upper Magnesian Limestone, Blackhall Rocks, 5 miles N. of Hartlepool. *C. T. Trechmann Colln.*, British Museum (Natural History), no. V.35111. × 3.

FIG. 7. *Tubulites permianus* (King). Upper Magnesian Limestone (concretionary beds), Easington. *C. T. Trechmann Colln.*, British Museum (Natural History), no. V.35113. × 2·4.

FIG. 8. Same species. Transverse sections of tubes. Upper Magnesian Limestone, depth 4,240 ft., Eskdale borehole no. 3, Sleights, near Whitby. Geological Survey, no. PF625. × 5.

FIG. 9. Same species. Longitudinal sections of tubes. Same borehole and depth as the preceding. Geological Survey, no. PF624. × 5.



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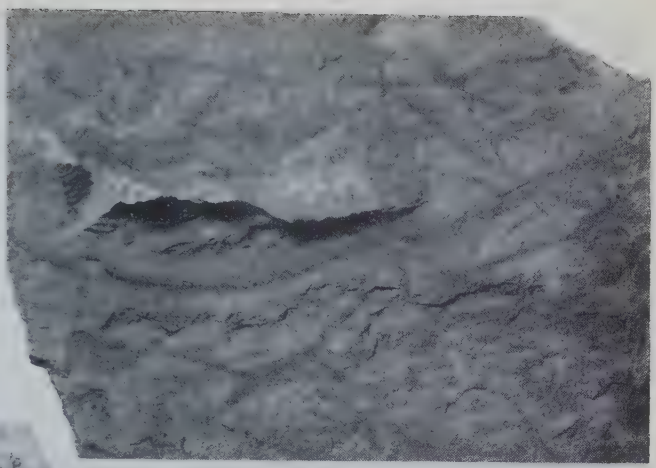

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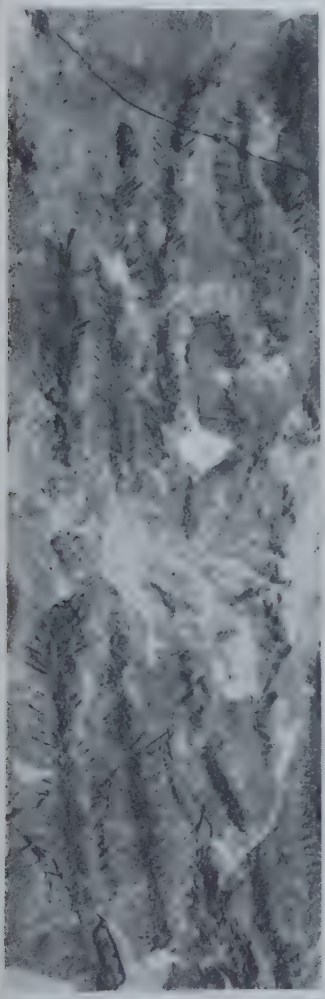

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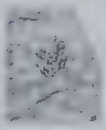

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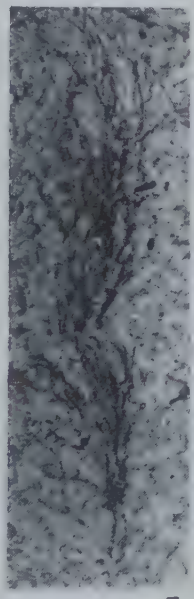

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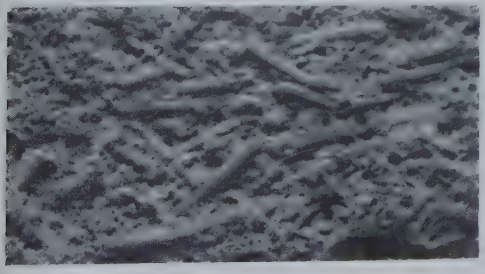

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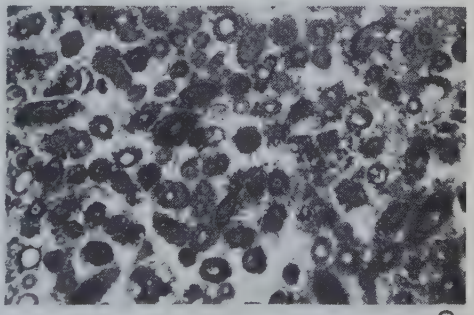

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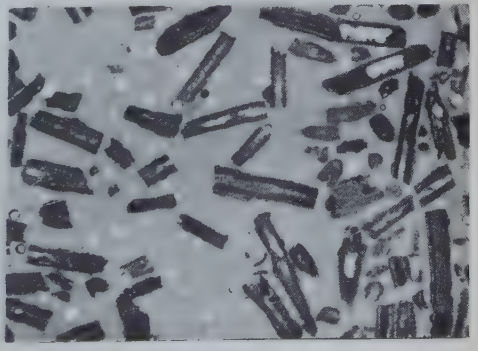

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PLATE 37

FIG. 1 *Paracalamites kutorgai* (Geinitz) Zalessky. Enlarged view of part of flattened stem fragment, with a node near left of figure. Marl Slate, Fulwell Water Works, near Sunderland. Hancock Museum. × 3, approx.

FIG. 2. *Callipteris martinsi* (Kurtze) Zeiller. Cuticle, showing a stoma with a prominent papilla. Marl Slate, Kimberley. British Museum (Natural History), no. V.5963*i*. × 200.

FIG. 3. *Taeniopteris eckardti* Kurtze. Marl Slate, Middridge. Hancock Museum. (*a*) × 1 ; (*b*) part of specimen, × 2, showing details of veins.

FIG. 4. *Mixoneura* sp. Pinnule from the holotype of *Neuropteris huttoniana* King. Marl Slate, Thrislington Gap, near Ferryhill. University College, Galway. × 2·3.

FIG. 5. *Callipteris martinsi* (Kurtze) Zeiller. The pinnules show a midrib and veins, also, at their base, scars of unknown origin. Marl Slate, Kimberley. British Museum (Natural History), no. V.5960. × 1·5.

FIG. 6. *Sphenopteris bipinnata* (Münster) Geinitz. Hilton Plant Beds, Hilton. British Museum (Natural History), no. V.35116. × 1·4.

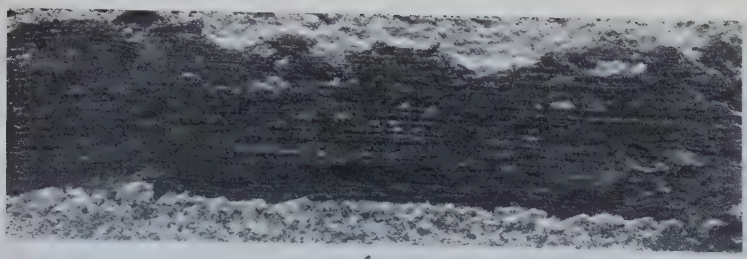
FIGS. 7, 8. *Schützia* ? sp. Crushed specimens possibly belonging to the same species as Figs. 9–12, but with the sporophylls (?) relatively few and distinct. Hilton Plant Beds, Hilton. British Museum (Natural History), nos. V.35120–21. × 1.

FIG. 9. *Schützia* ? sp. Two associated cup-shaped sporangial aggregates, preserved almost uncompressed but with their structure obscure. Hilton Plant Beds, Hilton. *C. T. Trechmann Colln.*, British Museum (Natural History), no. V.20554. × 1.

FIG. 10. *Schützia* ? sp. Laterally crushed specimen, with the opened-out sporophylls clearly seen. Hilton Plant Beds, Hilton. British Museum (Natural History), no. V.35122. × 3.

FIG. 11. *Schützia* ? sp. Specimen crushed so as to present much the same aspect as Fig. 10. Hilton Plant Beds, Hilton. Royal Scottish Museum, no. 1957. 15.1. × 3.

FIG. 12. *Schützia* ? sp. Crushed specimen ; the under side with a hollow for stalk attachment is seen, but the outlines of individual sporophylls are mostly indistinct. Hilton Plant Beds, Hilton. Geological Survey, no. 19068. × 1.



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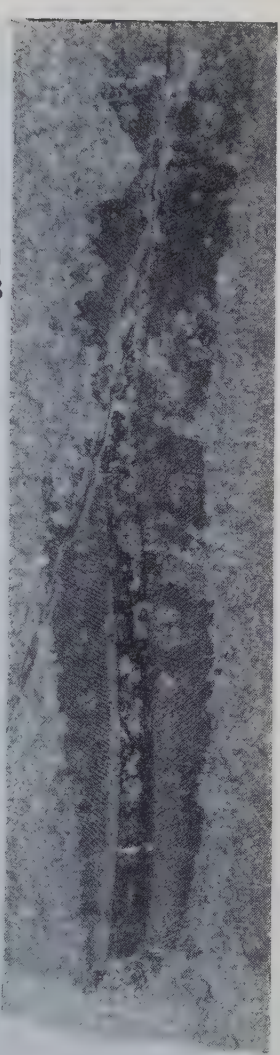

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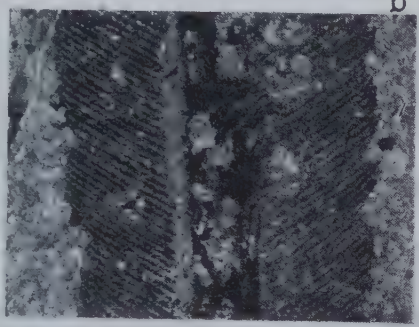

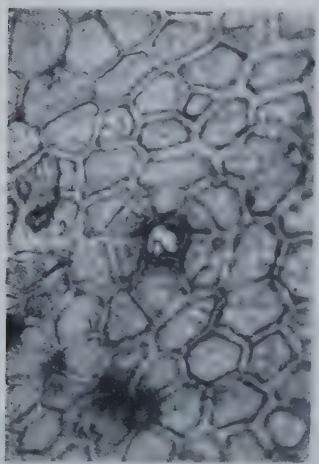

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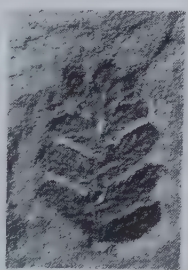

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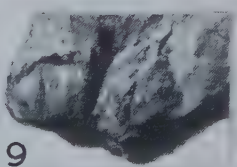

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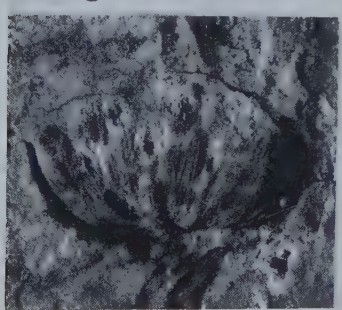

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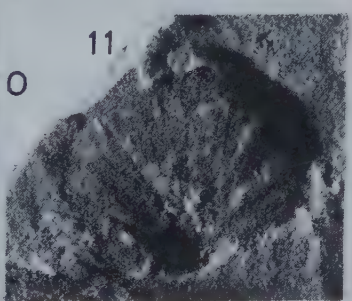

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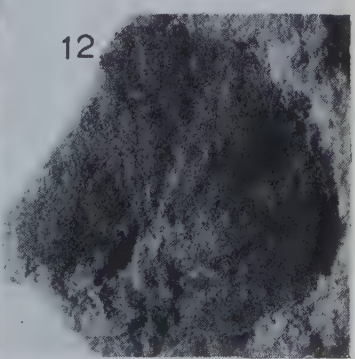

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PLATE 38

FIGS. 1*a*. *b*. *Ullmannia bronni* Göppert. Impression of a forking branch. Marl Slate, Raisby Hill Quarries, near Coxhoe. King's College, Newcastle-upon-Tyne. (*a*) Complete specimen. × 0·38, (*b*) part of specimen, showing densely imbricating leaves. × 0·77.

FIG. 2. Same species. Marl Slate, Middridge. Geological Survey, no. 19067. × 1.

FIG. 3. cf. *Cordaites aequalis* (Göppert) Zalessky. Leaf impression. Basement beds of Magnesian Limestone series, Fackley Hill, near Skegby. Geological Survey, no. 76680. × 1.

FIG. 4. Capsule of uncertain affinities, from bed containing *Sphenobaiera digitata* (Brongniart). Hilton Plant Beds, Hilton. British Museum (Natural History), no. V.35123. × 1.

FIG. 5. *Pseudoctenis middridgensis* sp. nov. Portion of rachis and bases of several pinnae, showing veins. Marl Slate, Middridge. Hancock Museum. × 1·8. (see also Text-fig. 12).

FIG. 6. *Sphenobaiera digitata* (Brongniart) Florin. Marl Slate, Middridge. Hancock Museum. × 1.

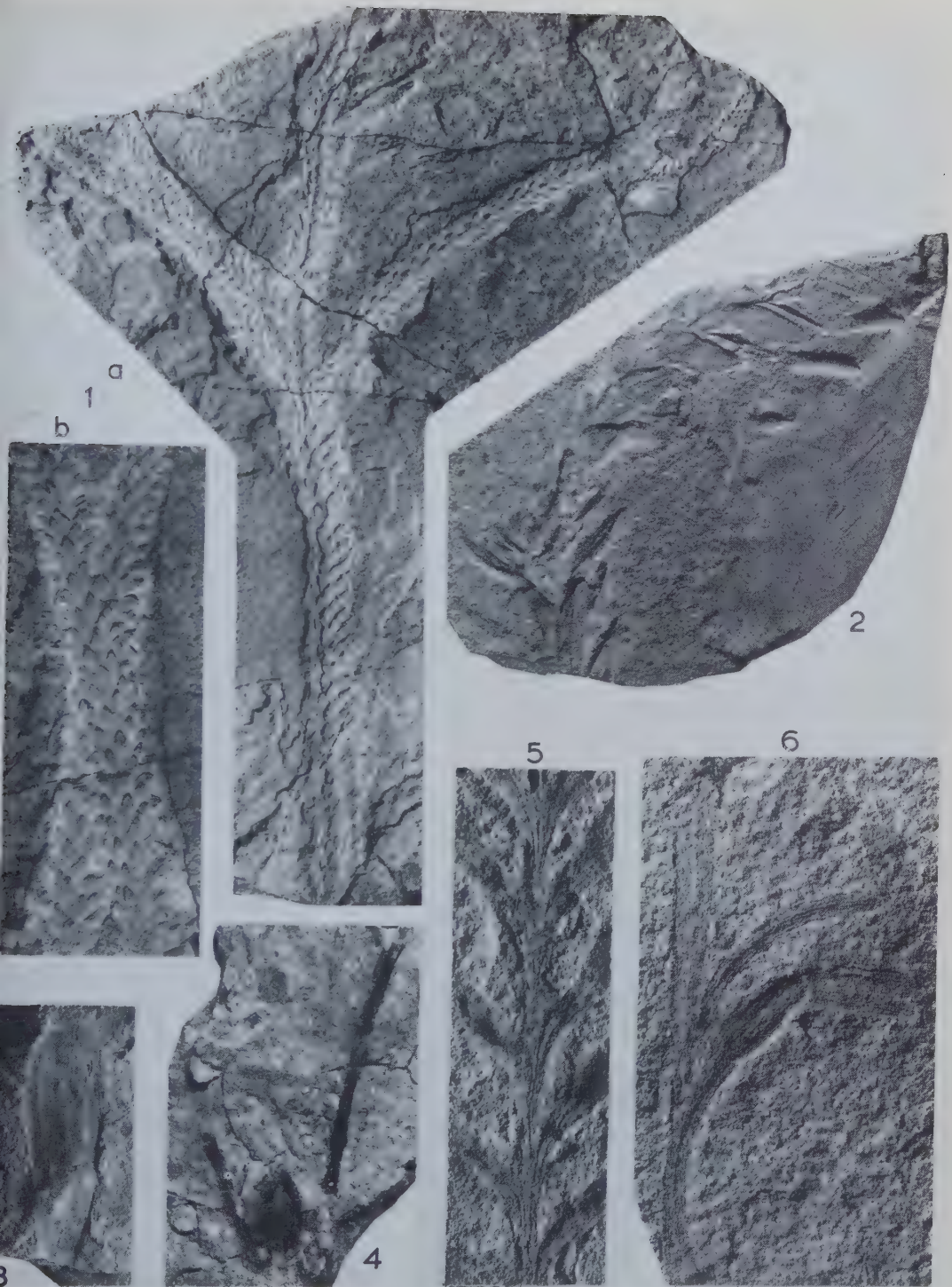
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PLATE 40

FIG. 1. *Pseudovoltzia liebeana* (Geinitz) Florin. Marl Slate, Thickley. King's College, Newcastle-upon-Tyne, no. 2525. × 1.

FIGS. 2, 3. *Samaropsis triangularis* (Geinitz) Seward. Marl Slate, Kimberley. British Museum (Natural History), nos. V.6210, V.6206. × 1.

FIG. 4. *Pseudovoltzia liebeana* (Geinitz) Florin. Marl Slate, Thickley. British Museum (Natural History), no. 46651. × 1.

FIG. 5. *Conites* sp. Near base of Upper Permian Beds, Bulcote borehole, near Nottingham. Geological Survey, no. 76681. × 2.

FIG. 6. *Pseudovoltzia liebeana* (Geinitz) Florin. Impression of cone scale. Marl Slate, Kimberley. British Museum (Natural History), no. V.6228. × 1.

FIG. 7. *Strobilites bronni* Solms-Laubach. Carbonized specimen. Hilton Plant Beds, Hilton. British Museum (Natural History), no. V.35124. × 1·5.

FIG. 8. Same species. Impression in sandstone. Hilton Plant Beds, Hilton. British Museum (Natural History), no. V.35125. × 1.

FIG. 9. Same species. Marl Slate, Kimberley. British Museum (Natural History), no. V.35126. × 1.

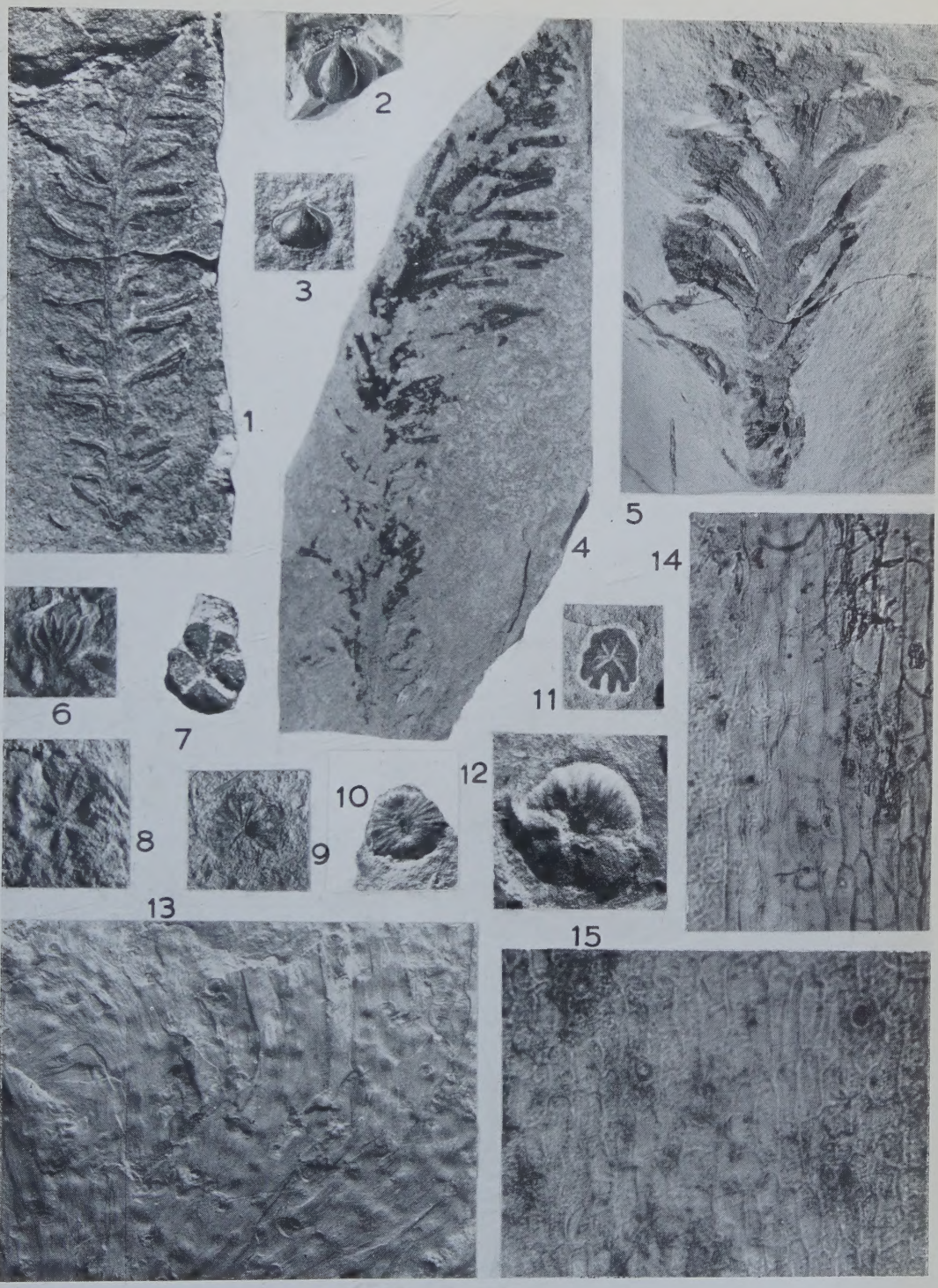
FIG. 10. Same species. Hilton Plant Beds, Hilton. Geological Survey, no. 19070. × 1.

FIG. 11. Same species. Marl Slate, Kimberley. British Museum (Natural History), no. V.35127. × 1.

FIG. 12. *Guilielmites permianus* Geinitz. A non-vegetable structure. Manchester Marls, Fallowfield. Manchester Museum, no. L.707. × 3·5.

FIG. 13. *Chondrus binneyi* King. A non-vegetable structure. Manchester Marls, Newton, Manchester. Geological Survey, no. 19048. × 1·7.

FIGS. 14, 15. ? *Psygmophyllum cuneifolium* (Kutorga) Schimper. Cuticle. Marl Slate, Middridge. British Museum (Natural History), nos. V.35133–34. × 150.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